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IBCS: AUTOMATED DISPLAYS

Harold B. Aldrich, et al

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70. Abstract (cont)

Objective 1. Determine how computer driven displays can best support the planning and control of tactical operations.

Objective 2. Evaluate proposed requirements statement under operational conditions and recommend changes as appropriate.

Objective 3. Evaluate the suitability of candidate computer driven display technological approaches to meet proposed requirements criteria.

Three automated display systems were evaluated. Each system differed in the technology used to rear project dynamic symbology (military unit symbols, alphanumerics, and graphics) onto a large screen. The systems had similar hardware configurations. The operation of each was controlled by a mini-computer which processed displayable data and caused the appropriate symbols to be displayed on the large screen and on a cathode-ray tube (CRT) display console. Each system displayed map backgrounds and formats on the large screen by means of slides. Each system also included a CRT display console and a number of other devices for the input or output of data.

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PART ONE - SUMMARY AND EVALUATION

CHAPTER 1 - Summary

I-1. Purpose.

a. The automated displays experimentation program examined three candidate automated display technologies to evaluate system technical requirements and to ascertain how automated display systems can best support the planning and control of tactical operations. This general purpose was translated into three objectives:

- (1) Objective 1. Determine how computer driven displays can best support the planning and control of tactical operations.
- (2) Objective 2. Evaluate proposed requirements statement under operational conditions and recommend changes as appropriate.
- (3) Objective 3. Evaluate the suitability of candidate computer driven display technological approaches to meet proposed requirements criteria.

b. Completion of objective 1 provided a baseline against which the findings in objectives 2 and 3 could be referenced. Objective 2 focused on evaluating, refining, determining, and stating technical performance requirements for automated display systems that are envisioned for use by the operations and intelligence staff sections in division tactical operations centers (DTOC's). The display requirements that were evaluated are listed in the materiel need (MN) document for the tactical operations system (TOS). Objective 3 was achieved by assessing the performance of the three candidate automated display systems against the requirements stated in objective 2.

I-2. Description of Experimentation.

a. System description. Three automated display systems were evaluated. Each system differed in the technology used to rear project dynamic symbology (military unit symbols, alphanumeric, and graphics) onto a large screen. The systems had similar hardware configurations. The operation of each was controlled by a minicomputer which processed displayable data and caused the appropriate symbols to be displayed on

the large screen and on a cathode-ray tube (CRT) display console. Each system displayed map backgrounds and formats on the large screen by means of slides. Each system also included a CRT display console (two consoles with the scribe system) and a number of other devices for the input or output of data.

(1) The scribe system used commercial hardware components and was developed by the Lockheed Corporation. Dynamic symbology for projection onto a 5-foot by 5-foot screen was computer generated and mechanically etched on a metal coated glass slide by one of two scribing projectors. Two reference projectors displayed map backgrounds, and a spotting projector displayed a marking cursor. Each of the five projectors was capable of displaying symbols in one of six colors: red, green, blue, orange, yellow, or white.

(2) The CRT system used commercial hardware components and was developed by the General Dynamics Corporation. The system used two cathode ray tube projectors (one red and one green) to display dynamic symbology on a 5-foot by 5-foot screen. Map backgrounds which were on 35-millimeter slides were projected onto the screen by a carousel projector.

(3) The photochromic system was a militarized system that was developed for the United States Army Materiel Command - Electronics Command (USAMC-ECOM) by the Singer Librascope Corporation. An ultra-violet laser provided a beam of high energy which was positioned by deflection mirrors to form the dynamic symbols on heat sensitive photochromic film. The generated symbols were illuminated by a xenon projector lamp and projected in blue onto a 6-foot by 4 1/2-foot screen. A second (blue-green) laser was used to display a marking cursor.

b. Test methodology. A brief description of how each experimentation objective was accomplished follows:

(1) Objective 1 - Determine how computer driven displays can best support the planning and control of tactical operations. MASSTER test reports, studies, field manuals, and other documents were researched in order to identify in general terms those tactical operations center (TOC) activities that used displays and to determine what those displays were. Based on this research, a questionnaire was designed and distributed to representative user personnel in units at Fort Hood. The replies were used to identify the information display requirements of those TOC activities which used displays. The net result of this entire effort was the identification of potential automated display users and their current (manual) display requirements.

(2) Objective 2 - Evaluate proposed requirements statement under operational conditions and recommend changes as appropriate. An evaluation of the data gathered during the experiment was used to identify and

qualify the performance requirements for automated display systems. The following factors were considered in the evaluation:

- (a) The group display device and analysis console component characteristics stated in the MN for TOS.
- (b) The current (manual) display requirements derived by completing objective 1.
- (c) Data collected during the 2-week command post exercise (CPX) portion of the experiment.
- (d) Component performance data collected during the performance testing portion of the experiment.
- (e) Special evaluator comments.
- (f) Data obtained from research of display system literature.

(3) Objective 3 - Evaluate the suitability of candidate computer driven display technological approaches to meet proposed requirements criteria. Performance data collected during the performance testing portion of the experiment was evaluated against the requirements derived from objective 2.

(4) Each of the three experimentation objectives was subdivided into subobjectives. Analysis of the subobjectives led to the identification of essential elements of analysis (EEA's) which asked the basic questions. Related EEA's which could best be answered together were grouped into discrete tasks called work segments. Each work segment was a complete package. The packages included detailed procedures for data collection, appropriate system inputs, data collection forms, and data reduction procedures. Part three of this report contains the subobjectives, EEA's, and work segment descriptions.

(5) Twenty-two work segments were identified. Three of the work segments required the display systems to receive and display data from the developmental tactical operations system (DEVTOS). One of the work segments was a 2-week CPX during which player personnel used two display systems (scribe and CRT) to assist in performing G2, G3, and battlefield information coordination center (BICC) activities in a CPX environment.

(6) Throughout the experimentation period, special evaluators from agencies outside of MASSTER observed the portions of the experimentation which related to their field of expertise and provided comments that contributed to both the experimentation and the findings. These agencies included Project Management Office, Army Tactical Data Systems; Computer

Systems Command; Army Research Institute; Defense Mapping Agency; Army Materiel Command - Electronics Command; Engineer Topographic Laboratory; and Combined Arms Combat Developments Activity.

(7) The experimentation was conducted in the Command, Control, and Communications Directorate workshop area during the period 12 February 1973 to 9 January 1974.

1-3. Findings.

a. Objective 1: Manual display requirements. A summary of the findings which pertain to the identification of potential automated display users and their current (manual) display requirements follows:

(1) The division, brigade, and battalion TOC activities which use information displays are identified in figure I-1.

Division	Brigade	Battalion
C2 (Operations-Plans)	S2	S2
G2 Air	S2 Intelligence Team	S2 Intelligence Team
G2 Intelligence Team (BICC)	(BICC)	(BICC)
G3 (Operations-Plans)	S3	S3
G3 Air	S3 Air	S3 Air
Fire Support Element (FSE)	Fire Support Coordination Center (FSCC)	FSCC
Airspace Control Element (ACE)	TACP	TACP
Signal Intelligence Support Element/ Electronic Warfare Element (SSE/EWE)		
Tactical Air Control Party (TACP)		

Figure I-1. Activities that use information displays.

(2) The majority of division, brigade, and battalion TOC activities use displays for rapid access to frequently referenced information to assist in planning and coordination. Intelligence activities use displays to assist in analysis. The majority of these displays require updating at least hourly. The number of required information displays range from 4 for the division and brigade TACP to 19 for the division G3 (Operations-Plans). The situation map is the most universally required display.

(3) Map backgrounds are required for division, brigade, and battalion TOC situation displays. The level of detail found on the present standard military map is not required for many of these displays. The amount of map detail required depends on the specific purpose of the display. Since maps with lesser detail are not in the current inventory, the map meeting the requirements of most TOC users is the standard military topographic map.

(4) The preferred map scale for use in the division, brigade, and battalion TOC is 1:50,000. At the division level TOC, a secondary preference is the 1:100,000 map scale.

(5) The number of colors used for displaying dynamic data is dependent on the requirement to readily distinguish between various information categories. Survey results from division, brigade, and battalion TOC users indicate that most situation displays require three colors (usually blue for friendly, red for enemy, and black for control measures). Black is also used on a contrasting background to depict letters and numbers on TOC charts. The colors presently used to depict topographic symbols on the standard tactical map sheets, as discussed in FM 21-31, are satisfactory at all TOC levels.

(6) The brigade and battalion TOC users prefer situation displays approximately 4-feet high by 4-feet wide. Division users prefer a display approximately 4-feet high by 5-feet wide. Chart or tabular status displays are approximately 3-feet high by 3-feet wide.

(7) The number of simultaneous viewers of displays during normal operations for the division, brigade, and battalion TOC is approximately four. For formal briefings the number of viewers depends on the echelon; up to 10 at battalion and up to 20 at brigade and division.

(8) The division, brigade, and battalion TOC's require from one to five copies of most overlays. The reproduction time required for the majority of division TOC overlays is approximately 15 minutes. Survey respondents indicate that a hard copy reproduction of approximately one-half of the essential division TOC overlays would be desirable for purposes of reference and dissemination.

b. Objective 2: Automated display system requirements. The findings for this objective are in two categories: findings which relate to automated display systems in general and findings which state the specific technical performance requirements for the devices of an automated display system.

(1) Automated display systems, general. An automated display system must integrate hardware, software, and the user for whom the software and hardware are designed. It is the user and his mission accomplishment which must be supported.

(a) Hardware. The MN for TOS identifies the group display device (GDD) and the analysis console (AC) as the devices required for display and manipulation of data in a TOC. The GDD and the AC are controlled by the TOS central computer. A brief description of the role of each device is provided below. A discussion of the experimentation findings relating to the hardware components of an automated display system follows the description.

1 The GDD has a large screen (4 by 4 foot minimum; 6 by 6 foot maximum) and is the primary operations and planning display device. The GDD portrays units, locations, boundaries, and zones or areas on a tactical map background. The GDD includes the overlay reproducer as a subcomponent to provide transparent overlays from displays on the GDD suitable for use with standard Army maps.

2 The AC provides the man-machine interface between the user and the system data base. It operates as a graphical display similar to the GDD and as an alphanumeric input-output device. The MN for TOS does not specify a capability for transfer of displays between the AC and the GDD.

3 Experimentation findings show two basic hardware components are required for any automated display system used in a division TOC. The first is a local display processor which allows for the receipt, storage, retrieval, display, and manipulation of data. The processor also controls the operation of the hardware components of the display system. The functions that the processor must perform dictate that it be separate from the TOS central computer and that it be dedicated solely to the operation of the display system. It is inefficient and impractical to require the TOS central computer to do the display data processing as well as control all the devices of the system. The problem is compounded when a number of display systems are linked to TOS, thus multiplying the total number of devices to be controlled. The separate display processor is not only more user responsive, but it also acts as the single point of contact for interaction between TOS and the display system. The display processor also facilitates "stand-alone" operation of the system and provides a built-in continuity of operations (CONOPS) benefit.

4 The second basic hardware component of an automated display system is the interactive graphic display console. This component is the primary user device for the display of, and interaction with, computer stored data. The console features which make this possible are a display surface dedicated to the presentation of displays for a specific user; the controls, such as a keyboard, joystick, and light pen with which the user can recall, create, modify, or delete displays; and a positive visual feedback on the display surface which allows the user to monitor display manipulation.

5 An automated display system from a hardware point of view contains basic components (a display processor and one or more interactive graphic display consoles) and other hardware components (peripheral devices) as required to meet particular user needs. Figure 1-2 shows how hardware components could be configured for a display system supporting one user, the division G3. To support an additional user such as the G2, the figure would also show dedicated interactive graphic display consoles for the G2. Other peripheral devices that the G2 requires would be added if sharing the use of a peripheral device (such as the printer for the receipt of messages or the map overlay input device for inputting overlays to the system) is unsatisfactory.

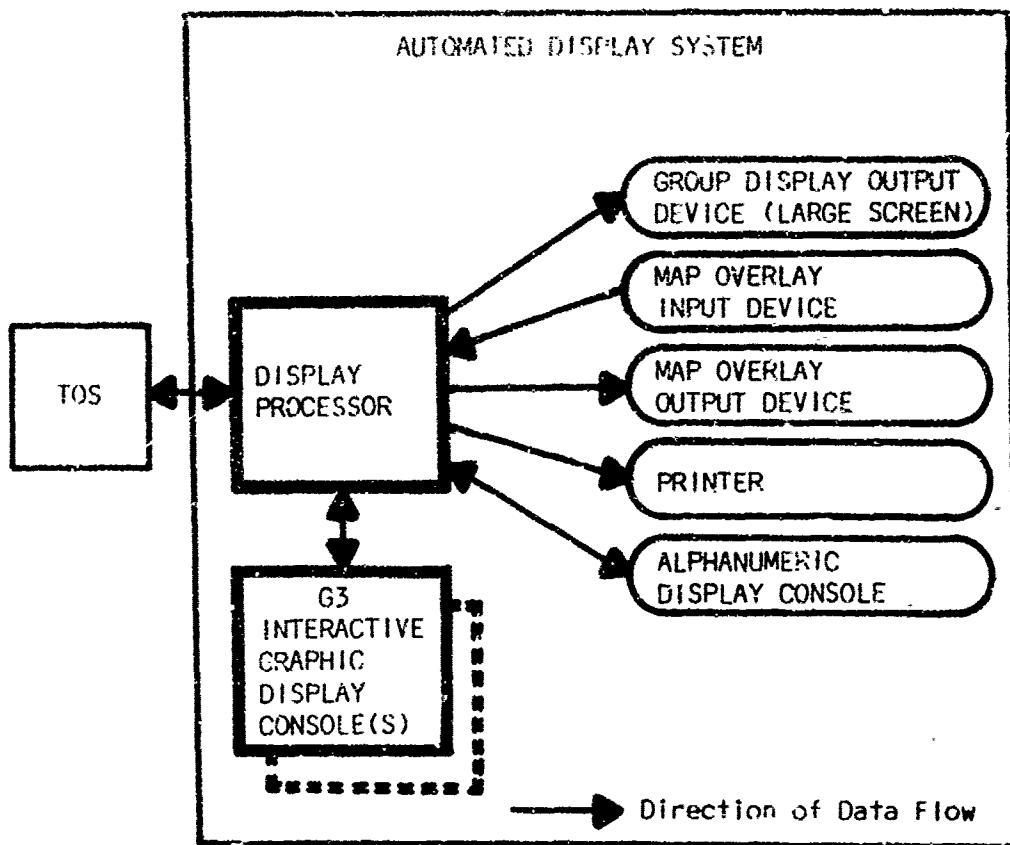


Figure 1-2. Type hardware configuration

6 In figure 1-2, the interactive graphic display consoles are the primary display devices. The group display output device (large screen) is shown as a peripheral output device to be included in the configuration only when anticipated usage justifies its inclusion. Control of displays on the large screen is accomplished through an interactive graphic

display console. Displays to be viewed on the large screen are first composed on the interactive graphic display console, then transferred to the large screen. This role of the group display output device was determined from data provided by users and special evaluators throughout the experimentation period and was initially identified from two observations during the CPX portion of the experimentation.

a During the CPX, the primary use of the large screen on both the scribe and CRT systems was for briefings. Although situation displays were portrayed on the large screens when they were not being used for briefings, the analysis console (editing console in the scribe system) was where the attention of key players was focused, where displays were manipulated, and where player reception of and reaction to incoming data occurred.

b The G2 and G3 sections formed a player group and used one system, while another player group (the BICC) used the other system. Since each system had only one usable console (the scribe system had a second console but its use interfered with the first) and one large screen, the G2 and G3 players were forced to share these devices. The majority of player comments indicated that the console display, although smaller, was satisfactory and was preferred over the large screen display mainly because the player could "do" more at the console because it was interactive. The comments also overwhelmingly favored separate, dedicated consoles for the G2 and G3.

7 The group display output device was not found to be an essential part of division level tactical display systems. However, experimentation findings do not nullify it as a potentially useful component of an automated display system. When current displays on a console need to be viewed by a large number of people during the course of a briefing, a device which provides for rapid display transfer and has a screen larger than that available on the console may be justified. When the device is not being used for briefings, it can be used to display the current situation for the benefit of all TOC personnel and visitors from other headquarters.

8 The requirement for a group display output device for a display system should be based on a cost-benefit analysis. The expected advantages must be considered against the additional volume, weight, and complexity imposed on the system. In each of the three systems evaluated, the large screen display components constituted a major part of the system's total volume and weight. Since the display system is expected to be housed in a vehicular-mounted shelter, volume and weight considerations will impact upon the number of shelters required and the overall system mobility.

9 The experimentation findings relating to the roles of the interactive graphic display console and the group display output device indicate a shift in emphasis from visualizing the large screen as the central, dominant component of an automated display system to stressing that the processor and the interactive console form the heart of the display system.

(b) Software. The key to user acceptance of an automated display system is proper definition of user requirements. Meeting the requirements is heavily software dependent. Suitable hardware is available or can be developed, but what the hardware is able to do for the user is largely a function of the software (i.e., the routines that perform the display functions which aid the user in accomplishing his mission).

1 After user requirements have been defined, software should receive first priority in the development of an automated display system. This does not mean that initial emphasis is to be placed on developing detailed logic flow diagrams. Rather, detailed answers should be obtained for the question: "What procedures should be designed to permit the user to meet his requirements with maximum ease?". The answers should define the software required. The software will provide vital guidance concerning hardware type and configuration.

2 This approach defines the user's needs and identifies the software required to meet these needs before the hardware is procured. The logic of this approach is better than the common practice of buying the hardware and then designing software to fit the hardware. Additionally, software comprises the bulk of system development cost, and therefore, should receive priority.

(c) User. The individual who will actually use the equipment in the field is the most important element in successful design of an automated system. The question asked in subparagraph (b) above can best be answered by this individual. His comments must be actively solicited by the hardware and software designers in all stages of system development. Violation of this principle could result in the fielding of a system which may be rejected in favor of the current manual operation because it does not do what is wanted, is too complicated to operate, or is simply too cumbersome.

1 An automated display system must satisfy different users in a TOC. The division G2 and G3 are considered separate users since they have different information requirements. For example, the G3 may be concerned with monitoring the maneuver of friendly units of battalion size and larger within the division area of operations. The G2 may be interested in an area different from that of the G3 and may require the display of particular enemy units and weapons located in his area of interest. User requirements will dictate the hardware configuration of an automated display system.

2 Automated display systems have the potential for easing the user's transition from manual to automated operations, because they present displays much like the user now employs. The display of data by an automated display system is preferable from a user standpoint to receiving the same data as computer printed copy for subsequent map posting.

3 The following quote from Parslow, Prowse and Green¹ is an excellent discussion of the role of an automated display system and particularly the interactive graphic display console. The application characteristics cited at the end of the quote are exactly those for an automated display system in a tactical operations center!

"Graphic data processing provides a common language of graphics and alphanumerics between the man and the computer. A man normally thinks in terms of sketches, drawings, graphs, letters, characters, and numbers. A computer operates in terms of bits, bytes, and registers. This makes it difficult for the man to communicate with the computer. In the past, the burden has been on the man; namely, he has had to convert all of his ideas and thoughts to letters, numbers, and a few special characters. The computer, in turn, converses back with the man in the same medium. With the advent of graphic data processing, the man can work in the medium he understands best; the computer can continue to work in the medium it understands best, with the graphic display console acting as an interpreter between the two. This new dimension in man/machine communication has proved to be of value in applications where: Graphic representation is of assistance in the performance of the application, or Rapid turn-around time is required, or Human imagination, judgement, or experience is required in the solution of the problem."

(2) Specific technical performance requirements. The major requirements that specific devices of an automated display system must meet are described below:

(a) Interactive graphic display console (individual display). Data from the CPX portion of the experimentation points out that user acceptance of an automated display system is greatly influenced by the ease with which the user can communicate (interact) with the system. The interactive graphic display console is the primary user device for performing this interaction. The availability and flexibility of the interactive capabilities and the degree to which the capabilities facilitate communication between the system and the user are major factors affecting the console's usefulness.

¹Computer Graphics, R.D. Parslow, R.W. Prowse, R. Elliot Green, Plenum Press, 1969.

1 The minimum interactive capabilities required for the graphic display console are listed below:

a. The console operator must be able to manipulate (add, delete, correct, move, or offset) any data item in a tactical situation display. Immediate visual feedback of the operator's actions is required for all manipulations.

b. The console operator must be able to store and display data items by category. When a new data item is added to the system's data base, the system must allow the user to specify which categories the data item is to be stored and displayed under.

c. The console operator must be able to store display scenes for later display and be able to manipulate the data items in any recalled scene.

d. The console operator must have the ability to obtain additional data on any displayed item upon request. Data items in tactical situation displays frequently have associated alphanumeric data (e.g., date time group, free text comments) which normally is not displayed with the symbol that represents the item; however, this information should be readily available when desired.

2 The primary purpose of the interactive graphic display console is to present tactical situation displays. The display consists of two parts: a map background and the dynamic symbology which is superimposed upon the background. The minimum map background capabilities required for the interactive graphic display console are listed below:

a. The console must be capable of displaying map backgrounds for comprehension of the overall tactical situation, for more detailed inspection of the terrain at or in the vicinity of a superimposed symbol, and for selective terrain analysis without superimposed symbology.

b. The user should be able to tailor the map background to the tactical situation. He should be able to specify the area of coverage by providing the console with the coordinates of any two diagonal corner points. He should also be able to specify the desired level of map detail by being able to display particular map features (e.g., grid lines, roads, rivers, contours) individually, or in combination, for the defined area of coverage.

c. When the console operator changes the map area of coverage, dynamic symbology must be automatically displayed at the appropriate map locations.

3 The minimum dynamic symbol capabilities required for the interactive graphic display console are listed below:

a The console must be able to display alphanumeric characters, selected FM 21-30 symbols, symbology added to the symbol generator by the user, circles, ellipses, and freehand graphics such as symbols for boundaries and axis of advance.

b A minimum of three colors is required. Three colors allow friendly, enemy, and control measure symbols to be color coded. Four to six colors are desirable.

4 Displays on the console must be viewable. Viewability encompasses legibility of the dynamic as well as map symbology and comprehensibility of the display. The minimum requirements pertaining to viewability for the console displays are listed below:

a The operator should be able to easily identify any dynamic or map symbol on the display while working under normal office lighting. Full legibility with desk lamps only at each work space is marginally acceptable. To assist in achieving full legibility, the brightness of the dynamic data and the background must be independently controllable by the console operator. In addition, the colors selected for the display of dynamic symbology must have high contrast to the backgrounds the symbols will be displayed upon.

b The console display area must be large enough to display an overall division tactical situation (as a minimum, control measures and friendly units of battalion size and larger) with a minimum amount of symbol clutter but must not be so large as to cause the operator undue eyestrain or head movement.

5 Dynamic symbols superimposed upon the map background must meet user placement accuracy requirements. Current manual procedures for plotting symbols against the 1:50,000 scale standard military map have an inherent plotting accuracy. The average individual updating a map in the TOC will, with few exceptions, position a given symbol within 100 meters of its specified map location. Most display users in the operations and intelligence sections of the TOC are concerned with the effect that symbol placement accuracy has on the evaluation of the positional relationships of the displayed symbols. While some users may require greater accuracy, the inherent accuracy of manual map posting is acceptable to most users in the TOC. Data items superimposed against a map background on the interactive graphic display console must appear to the viewer to be no more than 100 meters from the specified map location.

(b) Group display output device. The primary purpose of the group display output device is to present displays of the overall division

tactical situation to an audience of at least 20 persons. The display is first composed and displayed on an interactive graphic display console before being transferred to the group display device and consists of two parts: a map background and the dynamic symbology which is superimposed upon the background.

1 The minimum map background capabilities required for the group display output device are listed below:

a The device must be capable of displaying map backgrounds for comprehension of the overall tactical situation.

b The map backgrounds displayed for comprehension of the overall tactical situation must be identical to those used on the interactive graphic display console for the same purpose.

2 The minimum dynamic symbol capabilities required for the group display output device are listed below:

a The device must be able to display the identical alphanumeric, military unit, and graphic symbols required for display on the console. The symbol style and proportion must match that on the console.

b A minimum of three colors is required. Three colors allow friendly, enemy, and control measure symbols to be color coded. Four to six colors are desirable.

3 Displays on the device must be viewable. Viewability encompasses legibility of the dynamic as well as map symbology and comprehensibility of the display. The minimum requirements pertaining to viewability for the group display output device are listed below:

a Each person in the audience should be able to easily identify any dynamic or map symbol under normal office lighting. Full legibility with ambient lighting set to the minimum required for note taking is marginally acceptable. To assist in achieving full legibility, the brightness of the dynamic data as well as that of the background must be independently controllable. In addition, the colors selected for the display of dynamic symbology must have high contrast to the backgrounds they will be displayed upon.

b The display area must be large enough to display the overall division tactical situation (as a minimum, control measures and friendly units of battalion size and larger) with a minimum amount of symbol clutter but must not be so large as to cause the audience undue eye-strain or head movement.

4 Displays on the device are transferred from an interactive graphic display console. Therefore, requirements which facilitate the transfer of displays must be met.

a Rapid transfer of displays is required to preclude audience inconvenience.

b Once the transfer of a scene from the console to the group display has been accomplished, the scene on the group display must be displayed independently of display scenes on the console in order that the console be free to display other scenes.

5 Dynamic symbols superimposed against a map background must meet user placement accuracy requirements. Data items superimposed against a map background on the group display output device must appear to the viewer to be no more than 100 meters from the specified location.

(c) Map overlay input device. The main purpose of the map overlay input device is the input of freehand graphic data such as that found on an operation overlay (e.g., symbols for boundaries, objectives, phase lines). A secondary purpose is the highlighting of map data (e.g., roads, rivers). Either use of the device requires that the overlay or the map sheet be placed on the device and the data be traced or input to the system in some manner.

1 A primary requirement for the device is ease of use. The procedures for registering the map sheet from which the overlay or map data is to be traced and the procedures for input of the data must be simple.

a Map registration must be performed by providing the system with only the coordinates of any two grid intersections diagonally located in relation to each other. Once registration is accomplished, reregistration should not be required until a new map is used. The map must not have to be exactly centered and vertical.

b Data items should be input by indicating the series of points which define each item. As each succeeding point of a data item is selected, the resulting cumulative line segment should be automatically connected and displayed on the interactive graphic display console. When inputting an item, the user must be able to specify the type of line desired (e.g., solid, dashed), the category that the item is to be displayed under, and the color of the item.

2 The device must meet user requirements for area of map coverage. The device must be large enough to accommodate the map area of coverage for the majority of division tactical situations. Experience indicates that this area is at least 50 kilometers by 50 kilometers. The size of this area on a scale of 1:50,000 (the scale of maps most widely used in the division) is 1 meter by 1 meter.

3 The device must also meet user requirements for accuracy of the input data. The map background used on the map overlay input device

must be registered so that a data item entered as a series of points on either the overlay or the map itself, when displayed on the console or group display, has the points displayed within 100 meters of the points entered thru the device.

(d) Map overlay output device. The map overlay output device provides hard copy or interactive graphic display console scenes.

1. The output, in the form of an overlay for use with standard paper maps, must meet the following requirements:

a. The device should have the ability to provide output to any scale desired. As a minimum, the operator must be able to specify scales of 1:25,000, 1:50,000, 1:100,000, and 1:250,000.

b. The output size must be large enough to accommodate the map area of coverage for the majority of division tactical situations. Experience indicates that this area is at least 50 kilometers by 50 kilometers. The size of this area on a scale of 1:50,000 (the scale of maps most widely used in the division) is 1 meter by 1 meter.

c. The overlay must be output on transparent material. However, this is not intended to exclude output on other material such as paper.

2. The overlay must match the scene displayed on the console and must meet the following requirements:

a. The device must be capable of outputting the identical alphanumeric, military unit, and graphic symbols required for display on the console. The symbol style and proportion must match that used for the console.

b. A minimum of three colors is required. Three colors allow friendly, enemy, and control measure symbols to be color coded. Four to six colors are desirable. Color selection should be based upon obtaining a high degree of contrast in relation to the map backgrounds the overlays will be displayed against.

3. Output from the device must be timely and must meet user accuracy requirements:

a. The device should be capable of multiple copy output. Multiple copy output must be rapid enough to preclude user inconvenience.

b. The data items on the overlay, when placed over the appropriate map, must be within 100 meters of the correct symbol locations. While this accuracy is tolerable for most uses of the overlay, other uses (e.g., targeting) may require greater accuracy.

(e) Printer. The printer provides hard copy of alphanumeric data. It must meet the following requirements:

- 1 The printer must have the capability to print the 64-character American Standard Code for Information Interchange (ASCII) set.
- 2 The printed characters must be fully legible in ambient light as low as the minimum required for reading high contrast or well-printed material.
- 3 The output must be sufficiently rapid to preclude user inconvenience and should be the standard 8-inch by 10 1/2-inch size to facilitate reproduction by existing equipment.
- 4 The print area must be visible to the user to preclude the possibility of output not being noticed or of having to advance the page to read newly received data.

(f) Alphanumeric display console. The alphanumeric display console is the primary device for the input, display, manipulation, and transmission of alphanumeric data,

1 The operator procedures for the functional capabilities of the console must be easy to use. The procedures recommended for the interactive graphic display console exemplify the degree of simplicity and user convenience desired.

2 Displays on the console must be viewable. Viewability includes legibility of the dynamic symbology as well as comprehensibility of the display. The minimum requirements pertaining to viewability for the alphanumeric display console are listed below.

a. The symbols required to be displayed on the console are the 64-character ASCII set. Message formats as well as tabular chart outlines will also be displayed.

b. Two colors are desirable. The second color allows message formats and tabular chart outlines to be readily distinguishable.

c. Displays on the console must be fully legible under normal office lighting.

d. The screen should be sufficiently large to present the required alphanumeric displays, but should not be so large as to cause undue operator eye and head movement.

c. Objective 3: Performance of evaluated automated display systems.

- (1) None of the three candidate systems evaluated during the experimentation fully met all of the requirements determined in objective 2 of the experimentation.
- (2) Evaluated collectively, the performance of the three systems demonstrated that available hardware and software technology have the potential to meet the automated display system technical performance requirements described in this report. These performance requirements should be used as the basis for further evolutionary development of automated display systems.
- (3) The CRT system demonstrated the best performance overall. The performance was attributable primarily to the system software design which provided more capability and flexibility in the display and manipulation of data than was demonstrated by the other two systems. The performance of the CRT system was enhanced by the use of a magnetic disk storage unit which allowed for a greater number of display routines than were provided by the other two systems. The routines were rapidly accessible by the display processor and were called upon as required.
- (4) None of the devices evaluated met all the requirements specified for the device. However, the devices of each system which demonstrated the greatest overall capability in meeting the requirements specified for the device are shown in figure 1-3.

System	Interactive graphic display console	Group display output device	Map overlay input device	Map overlay output device	Printer
Scribe		X			X
CRT	X		X		
Photochromic			NA*	X	NA*

*This device was not a component of the system.

Figure 1-3. Relative performance of system devices.

CHAPTER 2 - Conclusions and Recommendations

2-1. Conclusions.

- a. An automated display system (a display processor controlling several interactive graphic display consoles and other input or output devices as required) has the potential to improve the planning and control of operations in a division tactical operations center. Two major advantages of the system are the presentation of displays which are familiar to the user and the rapid and flexible response to user requirements. These advantages can provide data management capability superior to current manual means.
- b. The materiel need document for the tactical operations system (MN for TOS) requires revision. The revision must emphasize that the interactive graphic display console and a display processor integral to the system are the basic components of any display system envisioned for tactical use. The revision should also recognize that the integral display processor provides the automated display system with a "stand-alone" capability. The impact of this "stand-alone" capability should be investigated.
- c. Investigation to determine the specific user applications which can be effectively accomplished by an automated display system should be conducted. The technical performance requirements outlined in this report are the basic capabilities required as a point of departure for development of tactical automated display system applications.
- d. Although none of the three systems fully met the technical performance requirements arrived at as a result of the experimentation, evaluation of the collective performance of the systems indicates that available technology has the potential to meet the requirements stated. These performance requirements should be used as the basis for further evolutionary development of automated display systems.
- e. Evaluation of the performance of the three systems indicates the necessity for emphasis on careful and complete definition of user inputs and the outputs that the user expects the automated display system to provide. This definition has a great impact on the development of the appropriate software which in turn determines how well the system will meet the user's requirements.
- f. Experimentation using commercially developed hardware and software is an efficient and effective way to identify and refine performance capabilities required for automated display systems.
- g. The display of map backgrounds by an automated display system is not expected to totally replace the use of paper maps in the TOC. In this light, investigation to determine the best means for providing map backgrounds for automated display systems is required. A display

without usable map backgrounds is ineffective. The display of a map background is as important to the user as the display of the dynamic symbols superimposed on the background. The user should be able to tailor both the map area of coverage and the level of detail to the situation.

h. The selected display technology will determine the colors available for displaying dynamic symbology. The color capabilities of available and potential display technologies require further investigation to identify principles for the selection of colors. The contrast and brightness of the colors must be compatible with the map backgrounds they will be displayed upon. Therefore, the investigation should be conducted in conjunction with or be based upon the results of the study on map backgrounds.

2-2. Recommendations.

a. That continued experimentation with automated display systems be conducted with emphasis on the following actions:

(1) Identification of functional applications for automated display systems. In making this identification coordination should be made with qualified user personnel.

(2) Determination of the display system components required by potential users at division level initially and at other echelons if it is determined that automated display systems are required at these echelons.

(3) Investigation of alternative means of providing automated display system support to tactical operations centers to include "stand-alone" display systems supporting single users or echelons.

b. That the findings pertaining to automated displays in tactical operations centers and the findings pertaining to system technical performance requirements be used as a basis for revision of the appropriate portion of the MN for TOS document.

c. That a study be conducted to determine the best means of providing map backgrounds for automated display systems. The study should specifically focus on techniques which can be used to provide the automated display system user with the ability to tailor both the map area of coverage and the level of detail to the situation.

d. That the color capabilities of available and potential display technologies be further investigated to identify principles for the selection of colors to display dynamic symbology. The investigation should be conducted with or be based upon the results of the study on map backgrounds.

23 July 1974

IBCS: AUTOMATED DISPLAYS
Test Number FM116

PART TWO - TEST AND FINDINGS

CHAPTER I - General

Section I - Introduction

I-1. Purpose.

a. The automated displays experimentation program examined three candidate automated display technologies to evaluate system technical requirements and to ascertain how automated display systems can best support the planning and control of tactical operations. This general purpose was translated into three objectives:

(1) Objective 1. Determine how computer driven displays can best support the planning and control of tactical operations.

(2) Objective 2. Evaluate proposed requirements statement under operational conditions and recommend changes as appropriate.

(3) Objective 3. Evaluate the suitability of candidate computer driven display technological approaches to meet proposed requirements criteria.

b. Completion of objective 1 provided a baseline against which the findings in objectives 2 and 3 could be referenced. Objective 2 focused on evaluating, refining, determining, and stating technical performance requirements for automated display systems that are envisioned for use by the operations and intelligence staff sections in division tactical operations centers (TOC's). The display requirements that were evaluated are listed in the materiel need (MN) document for the tactical operations system (TOS). Objective 3 was achieved by assessing the performance of the three candidate automated display systems against the requirements stated in objective 2.

c. Objectives 2 and 3 are contained in the outline test plan (OTP). Objective 1 was added by MASSTER to identify the TOC activities which are potential users of automated displays, determine their current (manual) display requirements, and identify the components of an automated display system which could facilitate the operation of the TOC activities identified. The addition of the objective was approved by the test proponent (Combat Developments Command (USACDC)).

I-2. Background.

a. Experimentation with large screen displays was initiated in MASSTER Command Post Exercise (CPX) CP3. The purpose of the experimentation was to determine the feasibility of using computer-assisted large screen displays at the division level in a tactical environment. The initial phase consisted of experimentation with a large screen "stand-alone" display system which employed a scribing projection technique. The results indicated that computer driven display systems could be useful in the division tactical operations center (DTOC). The results also indicated that additional experimentation to define system performance requirements and evaluate available display technologies would be beneficial. An OTP was developed by USACDC to define the additional experimentation needed. This plan was designated as FMI16.

b. In June 1972 approval was received from the Department of the Army for a 6-month lease of two candidate automated display systems. Specifications were prepared to meet the objectives stated in the OTP. Competitive contracts were awarded to the Northrop Corporation for development of the scribe projection system and to the General Dynamics Corporation for development of the cathode-ray tube (CRT) projection system.

c. In addition to the scribe and CRT systems, a third automated display system was evaluated. The system was developed for the United States Army Materiel Command - Electronics Command (USAMC-ECOM) by the Singer Librascope Corporation, and it used a photochromic film projection technique. Although the system did not possess many of the hardware and software capabilities called for in the specifications prepared for the scribe and CRT systems, it did possess a number of capabilities which could be evaluated and compared with the other two systems. Only those portions of the FMI16 test plan applicable to the photochromic system were used.

I-3. System Description. Three automated display systems were evaluated. Each system differed in the technology used to rear project dynamic symbology (military unit symbols, alphanumerics, and graphics) onto a large screen. The systems had similar hardware configurations. The operation of each was controlled by a minicomputer which processed displayable data and caused the appropriate symbols to be displayed on the large screen and on a CRT display console. Each system displayed map backgrounds and formats on the large screen by means of slides. Each system also included a CRT display console (two consoles with the scribe system) and a number of other devices for the input or output of data. Detailed descriptions of the individual components of the three systems are contained in chapter 2, section III, Performance of evaluated automated display systems.

a. Scribe projection system.

(1) The scribe system used commercial hardware components and was developed by the Northrop Corporation. Figure 1-1 is a schematic diagram of the system. Dynamic symbology for projection onto a 5-foot by 5-foot screen was computer generated and mechanically etched on a metal-coated glass slide by one of two scribing projectors. Both projectors contained 40 slide positions which were separately addressable by the computer. Slides of map backgrounds and formats were projected onto the large screen by two reference projectors. Each reference projector contained 40 addressable slide positions. A fifth projector was used to highlight, by means of a marking cursor, symbols on the large screen. The cursor was also used for map background registration. The projectors used incandescent bulbs to display symbology on the large screen. Each of the five projectors was capable of displaying symbols in one of six colors: red, green, blue, orange, yellow, or white.

(2) An analyst and an editing console (both were CRT display devices) allowed the operator to interact with the system. Neither of the consoles had the capability to display map backgrounds on its display screen. Each console displayed dynamic symbology in one color (green on the editing console and white on the analyst console).

(3) A teletypewriter was used for system technical control. A medium speed printer provided output of alphanumeric data contained in the system data base.

(4) Freehand graphic data such as symbols for objectives, phase lines, and boundaries were input through the graphic input device. Hard copy output (not to scale) of displays was provided through the graphic hard copy reproducer. Storage and recall of display scenes were provided by the magnetic tape unit.

b. CRT projection system.

(1) The CRT system used commercial hardware components and was developed by the General Dynamics Corporation. Figure 1-2 is a schematic diagram of the system. The system used two CRT projectors (one red and one green) to display dynamic symbology on a 5-foot by 5-foot screen. Map backgrounds which were on 35-millimeter slides were projected onto the screen by a carousel projector. The carousel contained 80 computer-addressable slide positions.

(2) The analyst console, a rear-ported CRT display device, allowed the operator to interact with the system. Map backgrounds and formats were projected onto the face of the screen through a rear-port in the CRT. A carousel projector with 80 computer-addressable slide positions was used to project the backgrounds. The slide carousels on the console and large screen projectors were independently addressable. This allowed the display of backgrounds which were not necessarily the same. Dynamic symbology was displayed on the console screen in two colors: red and green.

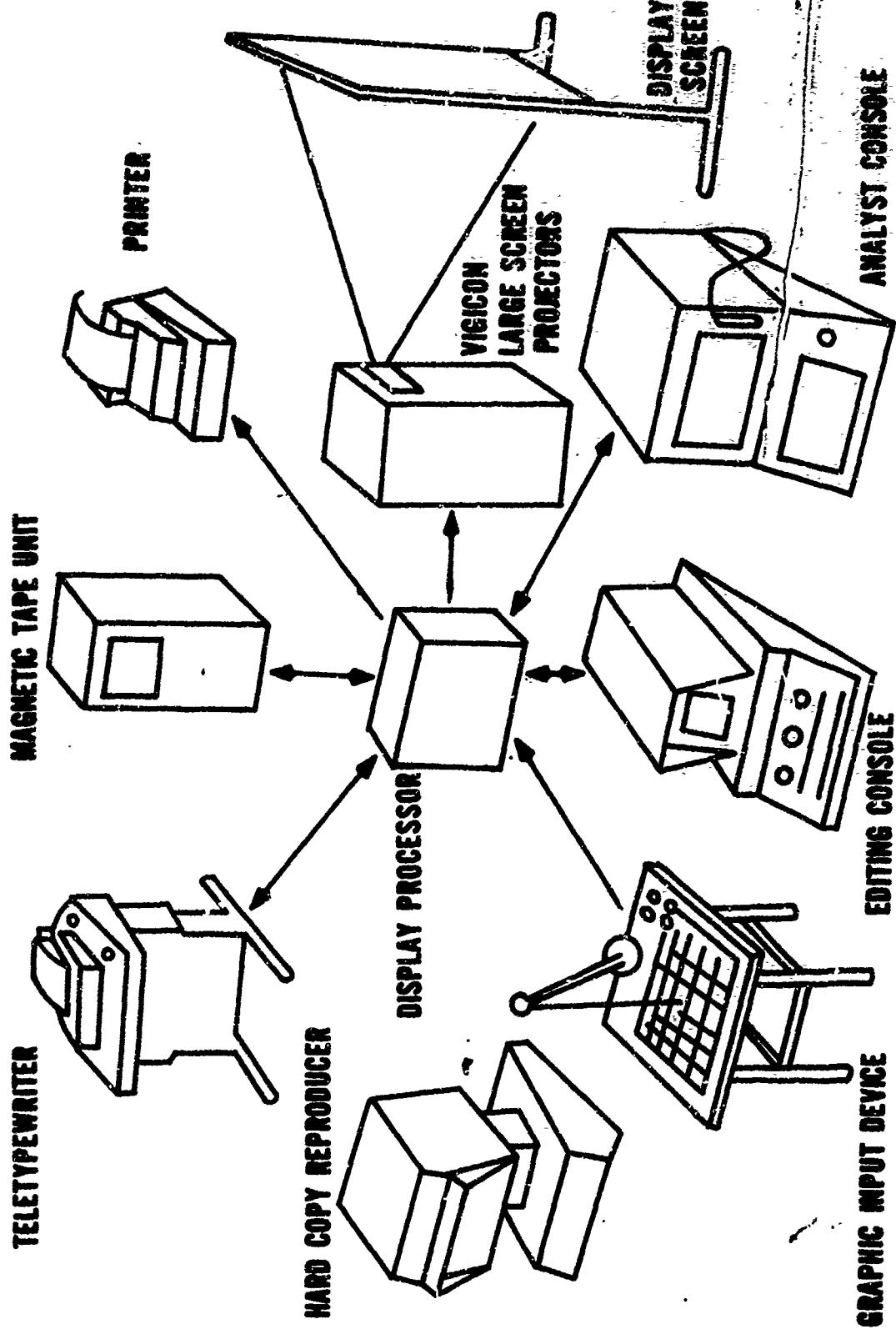


Figure I-1. Scribe projection system.

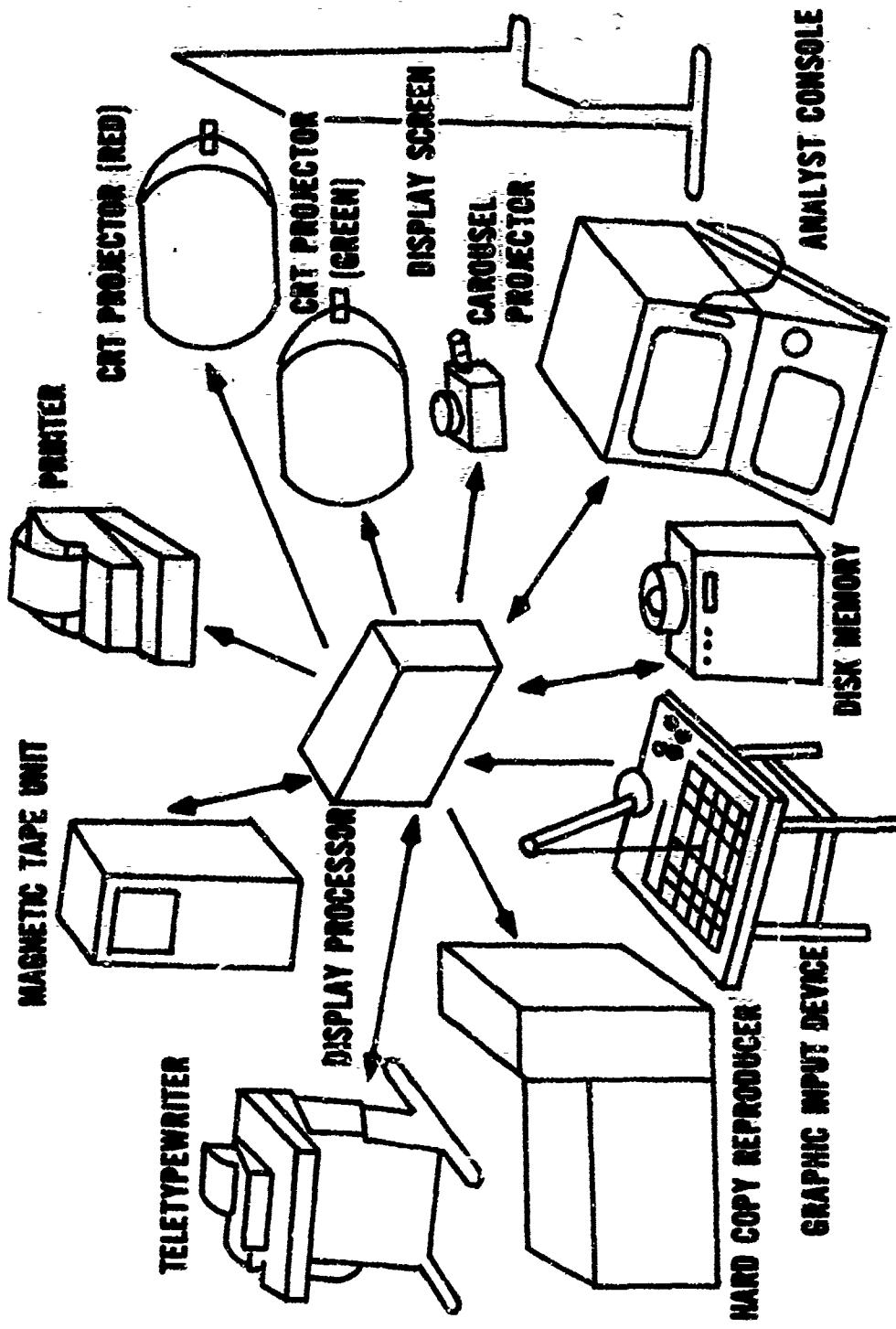


Figure I-2. CRT projection system.

(3) The teletypewriter, medium speed printer, graphic input device, and hard copy reproducer performed the same functions as those described for the scribe system. However, the output of the CRT system's hard copy reproducer was to scale. The magnetic tape and disk memory units allowed for storage and recall of displays.

c. Photochromic projection system.

(1) The photochromic system was a militarized system that was developed for the USAMC-ECOM by the Singer Librascope Corporation. Figure I-3 is a schematic diagram of the system. An ultraviolet laser provided a beam of high energy which was positioned by deflection mirrors to form the dynamic symbols on heat sensitive photochromic film. The generated symbols were illuminated by a xenon projector lamp and projected in blue onto a 6-foot by 4 1/2-foot screen. A second (blue-green) laser was used to display a marking cursor. The cursor allowed symbology to be visually located or highlighted at any location on the screen and also allowed registration of map backgrounds. Map backgrounds and formats were contained in a 70-millimeter revolving slide container. The container had 60 computer-addressable slide positions.

(2) Operator interaction with the system was provided by the data edit and entry module (DEEM). This device included a CRT display and a separate keyboard console.

(3) The teletypewriter and hard copy reproducer performed the same functions as those described for the scribe system. The hard copy reproducer used a photochromic film writing technique similar to that used for the large screen and produced scale copies of display scenes on transparent material. No on-line storage of display scenes existed. Display scenes could be stored off-line by outputting them on the punched paper tape available on the teletypewriter.

Section II - Test Design

I-4. Test Methodology. A brief description of how each experimentation objective was accomplished follows:

a. Objective I - Determine how computer driven displays can best support the planning and control of tactical operations. MASSTER test reports, studies, field manuals, and other documents were researched in order to identify in general terms those TOC activities that used displays and to determine what those displays were. Based on this research, a questionnaire was designed and distributed to representative user personnel in units at Fort Hood. The replies were used to identify the information display requirements of those TOC activities which used displays. The net result of this entire effort was the identification of potential automated display users and their current (manual) display requirements.

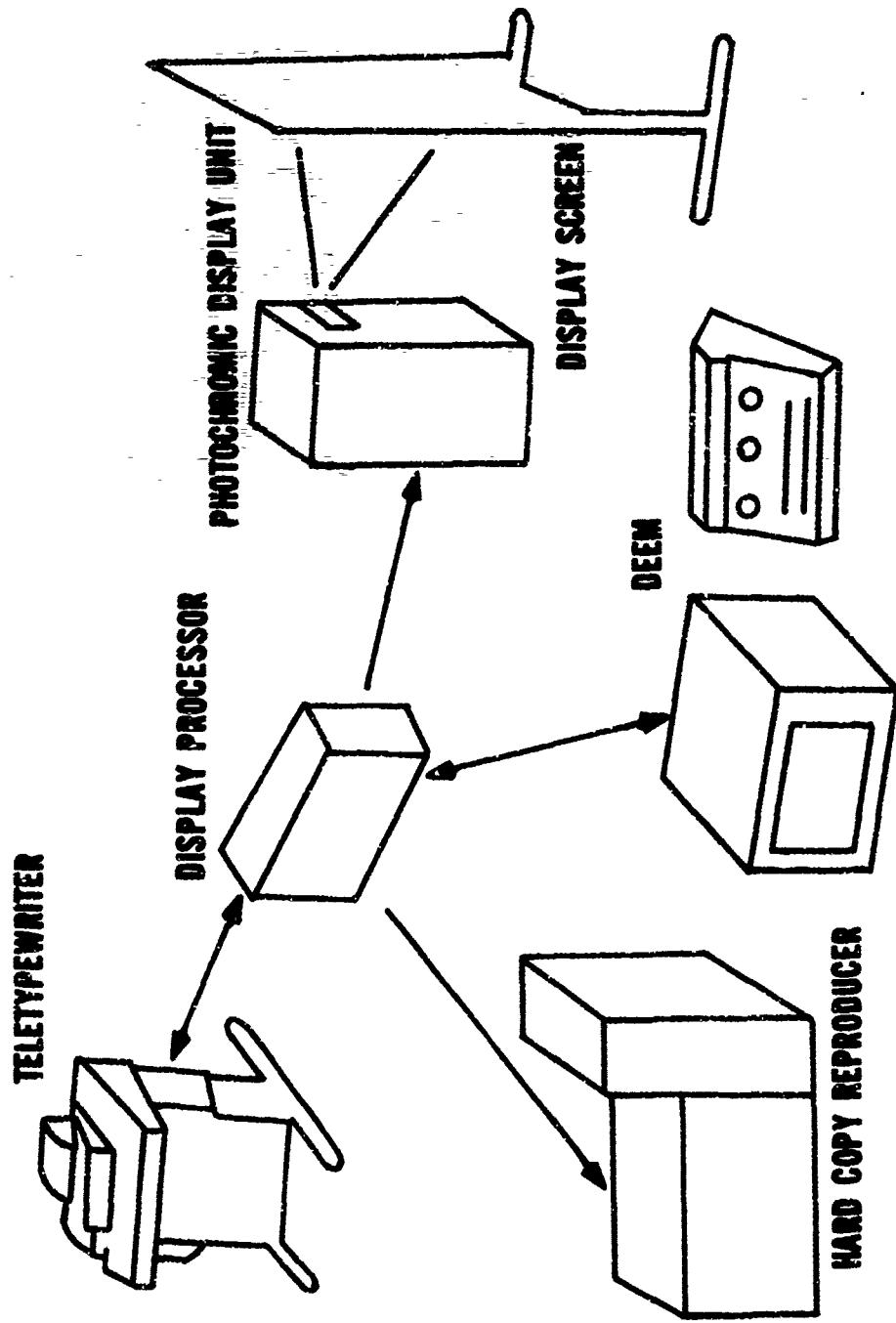


Figure I-3. Photochromic projection system.

b. Objective 2 - Evaluate proposed requirements statement under operational conditions and recommend changes as appropriate. An evaluation of the data gathered during the experiment was used to identify and qualify the performance requirements for automated display systems. The following factors were considered in the evaluation:

- (1) The group display device and analysis console component characteristics stated in the MN for TOS.
- (2) The current (manual) display requirements derived by completing objective 1.
- (3) Data collected during the 2-week CPX portion of the experiment.
- (4) Component performance data collected during the performance testing portion of the experiment.
- (5) Special evaluator comments.
- (6) Data obtained from research of display system literature.

c. Objective 3 - Evaluate the suitability of candidate computer driven display technological approaches to meet proposed requirements criteria. Performance data collected during the performance testing portion of the experiment was evaluated against the requirements derived from objective 2.

d. Each of the three experimentation objectives was subdivided into subobjectives. Analysis of the subobjectives led to the identification of essential elements of analysis (EEA's) which asked the basic questions. Related EEA's which could best be answered together were grouped into discrete tasks called work segments. Each work segment was a complete package. The packages included detailed procedures for data collection, appropriate system inputs, data collection forms, and data reduction procedures. Part three of this report contains the subobjectives, EEA's, and work segment descriptions.

e. Twenty-two work segments were identified. Three of the work segments required the display systems to receive and display data from the developmental tactical operations system (DEVTOS). Data transmission between DEVTOS and the display systems was one way only. However, display system users were able to input data to DEVTOS by the use of a message input-output device (MIOD) co-located with each display system. Three work segments did not require the display systems and were conducted before actual experimentation with the systems began. One of the work segments was a 2-week CPX during which player personnel used two display systems (scribe and CRT) to assist in performing G2, G3, and battlefield information coordination center (BICC) activities in a CPX environment.

f. A number of the work segments required the display of map backgrounds. A conference was held at Fort Hood on 25 and 26 July 1972 to determine the map backgrounds to be displayed by the candidate systems during the experimentation. Attendees at the conference were representatives from the Defense Mapping Agency, Army Tactical Data Systems, Human Engineering Laboratory, Behavioral Science Research Laboratory, United States Army Materiel Command-Electronics Command, Engineer Topographic Laboratory, Combat Developments Command, Tactical Systems Development Group, Computer Systems Command, Northrop Corporation, General Dynamics Corporation, and MASSTER. The map area of coverage selected was the same as that used on MASSTER Test 113, a command and control CPX. This allowed the use of the CPX tactical scenario input messages which were available from a DEVTO5 log tape. Both the scribe and the CRT systems used a rear projection technique for background display. Personnel at the conference determined the types of map backgrounds to be used and the area of coverage of each slide. They also determined that slides which displayed varying levels of map detail up to and including that found on the 1:50,000 scale standard military topographic map would be prepared. The Defense Mapping Agency produced the slides in accord with specifications provided by MASSTER. Details of the specific map backgrounds used during the experimentation are contained in chapter 2, section III, subparagraph 2-7b.

I-5. Test Events. The major test event dates are listed below.

- | | |
|--|------------------|
| a. Test plan in process review | 12 Dec 72 |
| b. Displays experimentation (scribe) began | 12 Feb 73 |
| c. CPX (scribe, CRT) | 30 Apr-11 May 73 |
| d. Displays experimentation (CRT) began | 21 May 73 |
| e. Displays experimentation (photochromic) began | 29 Oct 73 |
| f. Test concluded | 9 Jan. 74 |

I-6. Training.

- a. Personnel from HQ, MASSTER and Fort Hood units participated in the experimentation. The amount of training they received on the CRT and scribe systems is shown in figure I-4. Training on the photochromic system consisted of 4 weeks for two operators and 1 week for six test controllers.

Type of personnel	Number of personnel	Unit	Amount of training (week)
Test control team (Controllers, data collectors, data reducers)	8	HQ, MASSTER (CC and C Dir)	1
Display team (Operators) CPX players (G2/G3)	5/10*	2d Armored Division HQ, MASSTER (CC and C Dir)	4 1
BICC	8	163d Military Intelligence Battalion (Combat)	1

*10 were used during the CPX only.

Figure I-4. Personnel training.

b. Enlisted men served as display team personnel. They were required to have 20/20 vision and could not be color blind. These visual requirements were imposed, since selected individuals from the display team were used as test subjects for legibility experiments.

I-7. Logistics. Hardware and software support for each system was provided throughout the experimentation period by on-site vendor personnel.

Section III - Test Execution

I-8. General.

a. The test plan called for simultaneous experimentation with the scribe and CRT systems. However, the late delivery of the CRT system necessitated separate experimentation. This was not a problem since identical inputs provided to one system for a particular work segment could also be provided to the other system.

b. The scribe and CRT systems were both operational during the CPX. During this 2-week period, the G2/G3 player team and the BICC team used separate display systems to assist in performing their missions. The teams were rotated at the end of the first week so that by the end of the CPX each team had an equal amount of time on both systems.

c. Hardware and software limitations of the photochromic system precluded some of the 22 work segments being conducted with the system. The system did not have the required routines for DEVTOS interface. Consequently, the work segments, except work segment 5, which required data receipt from DEVTOS (including the CPX) were not conducted.

In work segment 5, paper tape was used to simulate DEVTOS message receipt. Other work segments which required experimentation with capabilities that the system did not have were also omitted.

d. Throughout the experimentation period, special evaluators from agencies outside of MASSTER observed the portions of the experimentation which related to their field of expertise and provided comments that contributed to both the experimentation and the findings. These agencies included Project Management Office, Army Tactical Data Systems; Computer Systems Command; Army Research Institute; Defense Mapping Agency; Army Materiel Command - Electronics Command; Engineer Topographic Laboratory; and Combined Arms Combat Developments Activity.

I-9. Test Control.

a. The work segments provided the framework of control for the experimentation. Before each work segment was conducted, the controllers, data collectors, and operators were thoroughly familiar with the work segment procedures. During each work segment, the controllers insured that the step-by-step procedures were being followed and that the collected data was complete.

b. The scope of the experimentation was such that the test controllers and key data collectors were involved in the entire test cycle. These key individuals planned, conducted the experimentation, reduced the data, and wrote the test report.

I-10. Uncontrolled Test Variables. The experimentation was randomly delayed for varying periods of time by system hardware and software failures. High humidity contributed to some of the hardware failures. A list of failures encountered on each system is contained in part three, section IV.

I-11. Environmental Conditions.

a. The experimentation was conducted in the Command, Control, and Communications Directorate workshop area. The scribe system was located in bunker number 92159. The photochromic system arrived after the scribe system had been removed. It was also located in bunker number 92159. The CRT system was located in bunker number 92161. The dimensions of the bunker are shown in figure I-5. The bunker locations are shown in figure I-5.

b. Modifications were made to the bunkers prior to the experimentation. A 16-foot by 20-foot plywood panel was suspended from the bunker ceiling. It was suspended 8 feet from the floor and 21 inches in front of the partition which contained the large screen. A schematic drawing of the panel or false ceiling is shown in figure I-7. The panel supported five rows of General Electric, F40 CWX, mainlighter, deluxe,

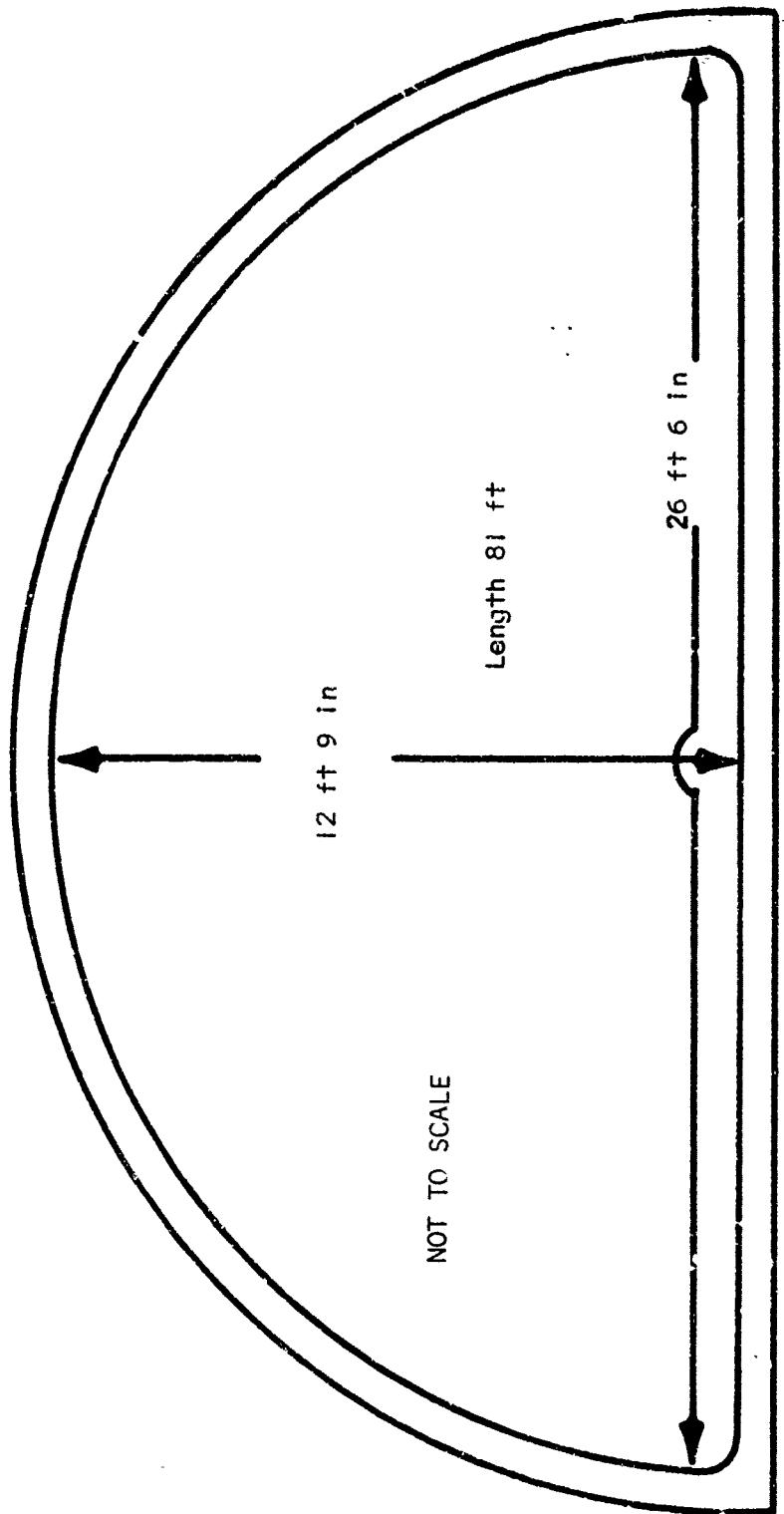


Figure I-5. Bunker dimensions.

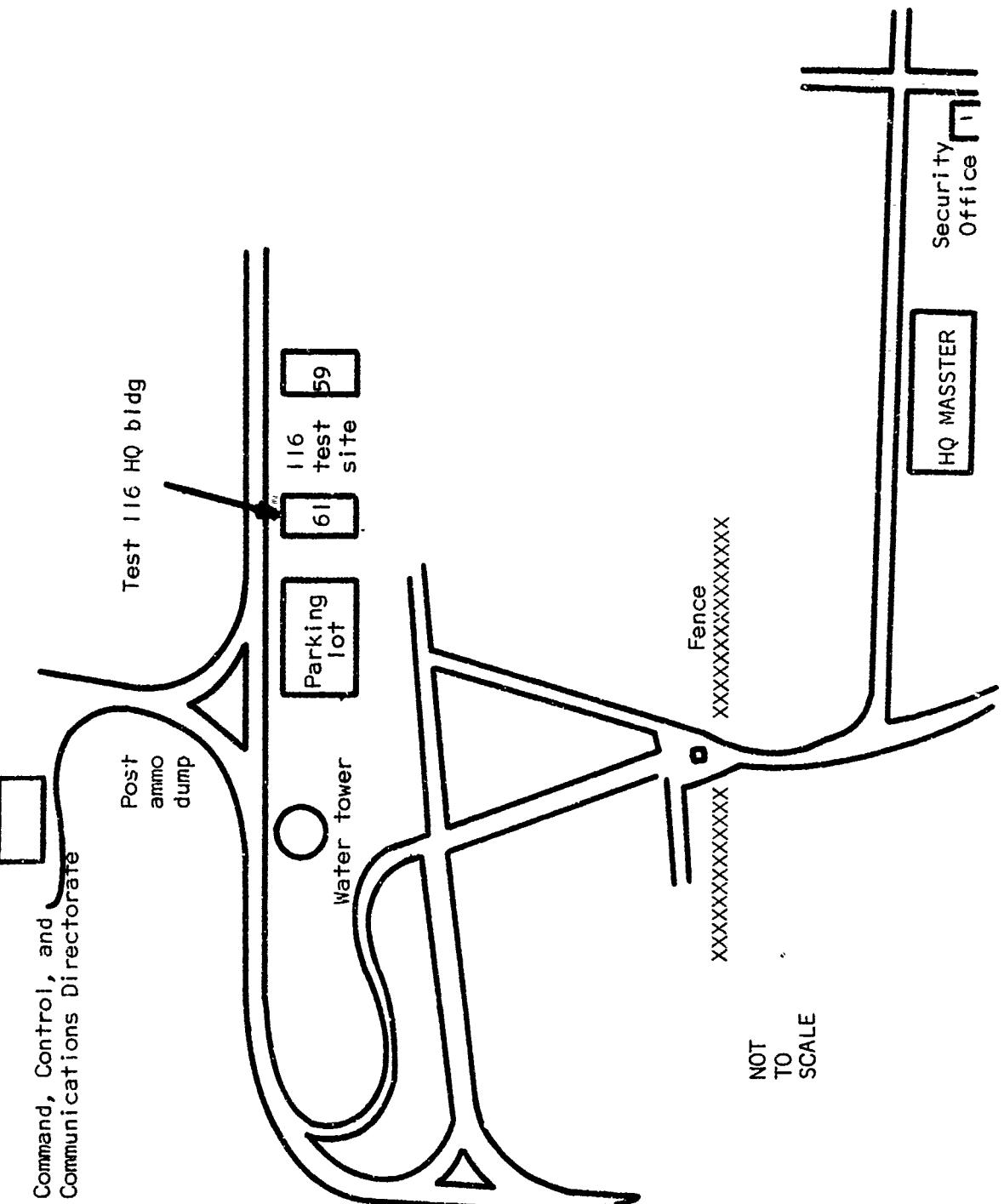


Figure 1-6. Bunker locations.

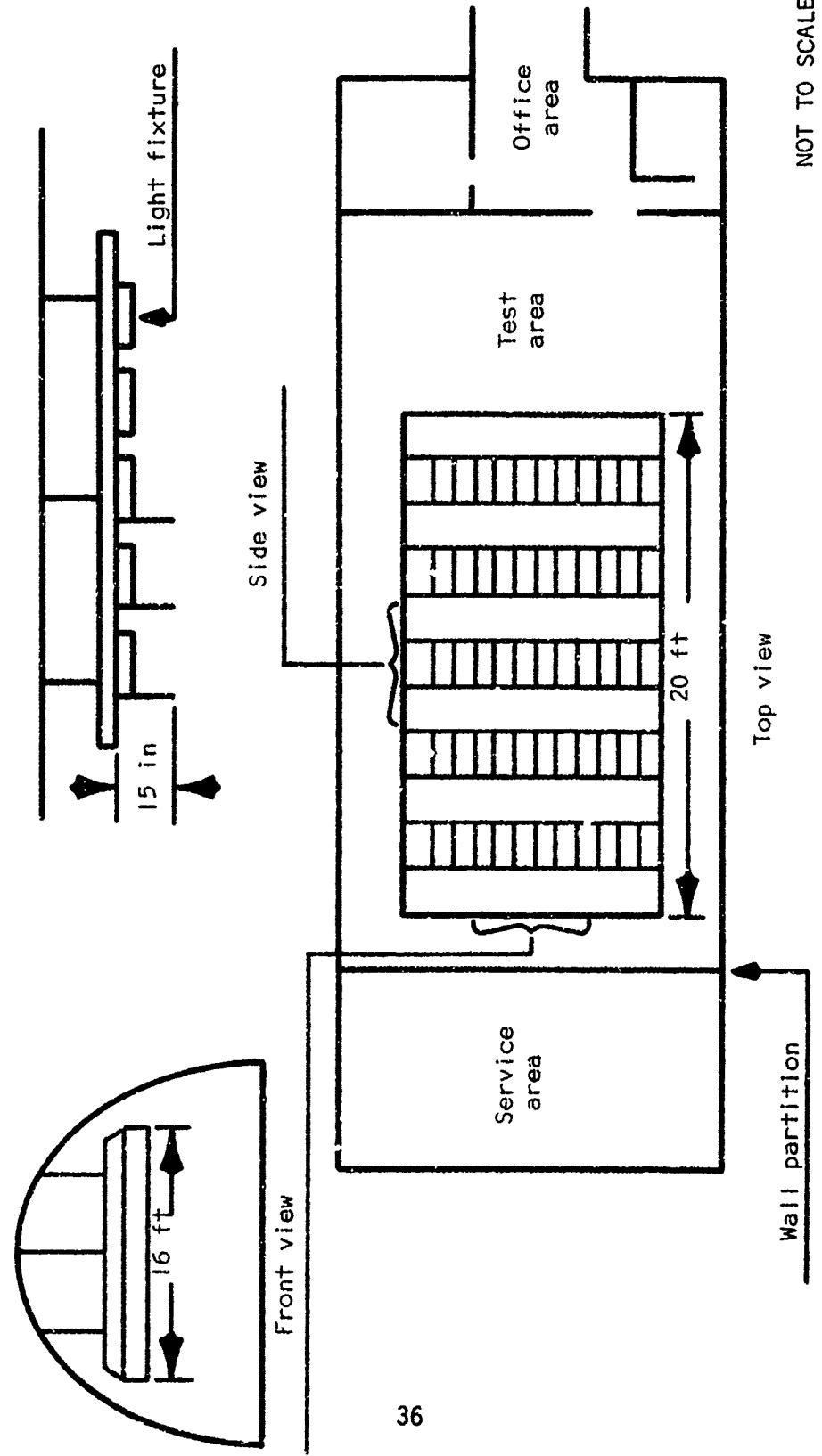


Figure 1-1. False ceiling.

cool white fluorescent lamps. Each row contained four double lamp fixtures. Lamp intensity was adjustable by a rheostat, and the two rows nearest the large screen were controlled independently by an on-off switch. Fifteen-inch plywood baffles were hung from the false ceiling in front of the first three rows of lamps to reduce glare on the screen. The panels were painted flat black and extended the full width of the false ceiling. The false ceiling was used to control the ambient light intensity in the experimentation area.

c. Each bunker was partitioned into a service area, a test area, and an office area. The bunker interior and the partition separating the test and service areas were painted flat white. This partition, on which the large screen was mounted, was made of 2-inch by 4-inch stud and sheetrock and extended from the floor to the ceiling. The partition in the rear of the bunker, separating the testing area from the administrative or office area, was a standard office divider with target cloth hung from the ceiling and attached to the divider. Two offices were partitioned off from the entranceway by using standard office dividers. The overhead lights in the bunker entranceway were shielded to project a minimum amount of light into the testing area. The lamps in the service area behind the large screen were the same type as those in the test area and could also be separately controlled with a rheostat. A schematic drawing of each bunker's layout for the three systems is shown in figures I-8, I-9, and I-10.

d. The bunkers had no heating or air conditioning equipment installed. Severe arcing in the CRT system's analyst console during system startup on very humid days necessitated the use of five portable dehumidifiers. The dehumidifiers were positioned near key components.

CHAPTER 2 ~ Test Findings

Section 1 - Manual Display Requirements

2-1. Survey Results.

a. This section addresses objective 1 of FMI 16 ~ Determine how computer driven displays can best support the planning and control of tactical operations. This objective has three subobjectives: identify those TOC activities which use information displays; identify the information display requirements of those TOC activities which use displays; and identify the automated display components which facilitate TOC activities. The data required to answer the first two subobjectives was collected by several means. First, MASSTER test reports, studies, field manuals, and other documents were researched to identify, in general terms, those TOC activities which use displays and to determine what these displays are. Next, a questionnaire was designed to obtain the

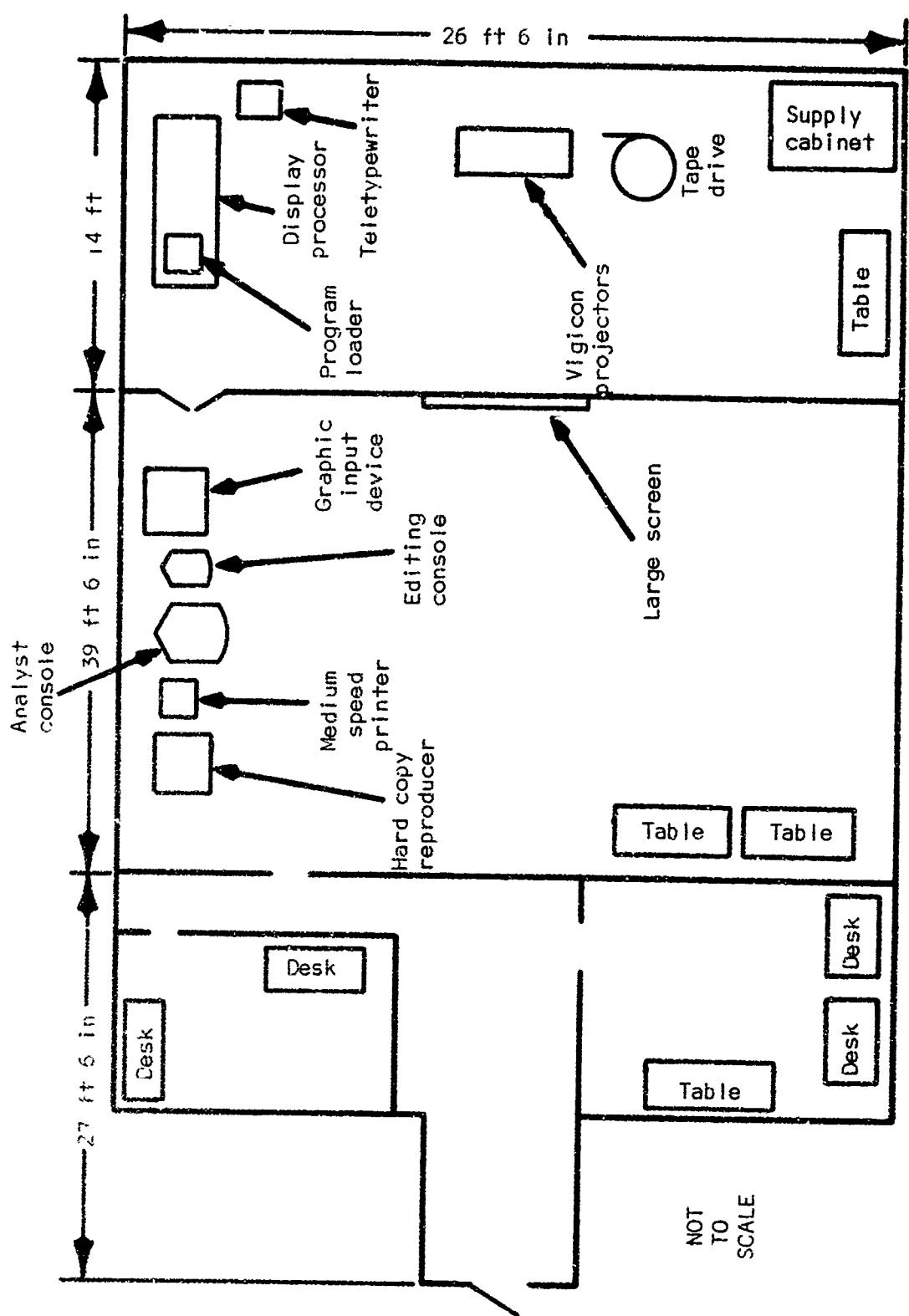


Figure 1-8. Bunker schematic, scribe system.

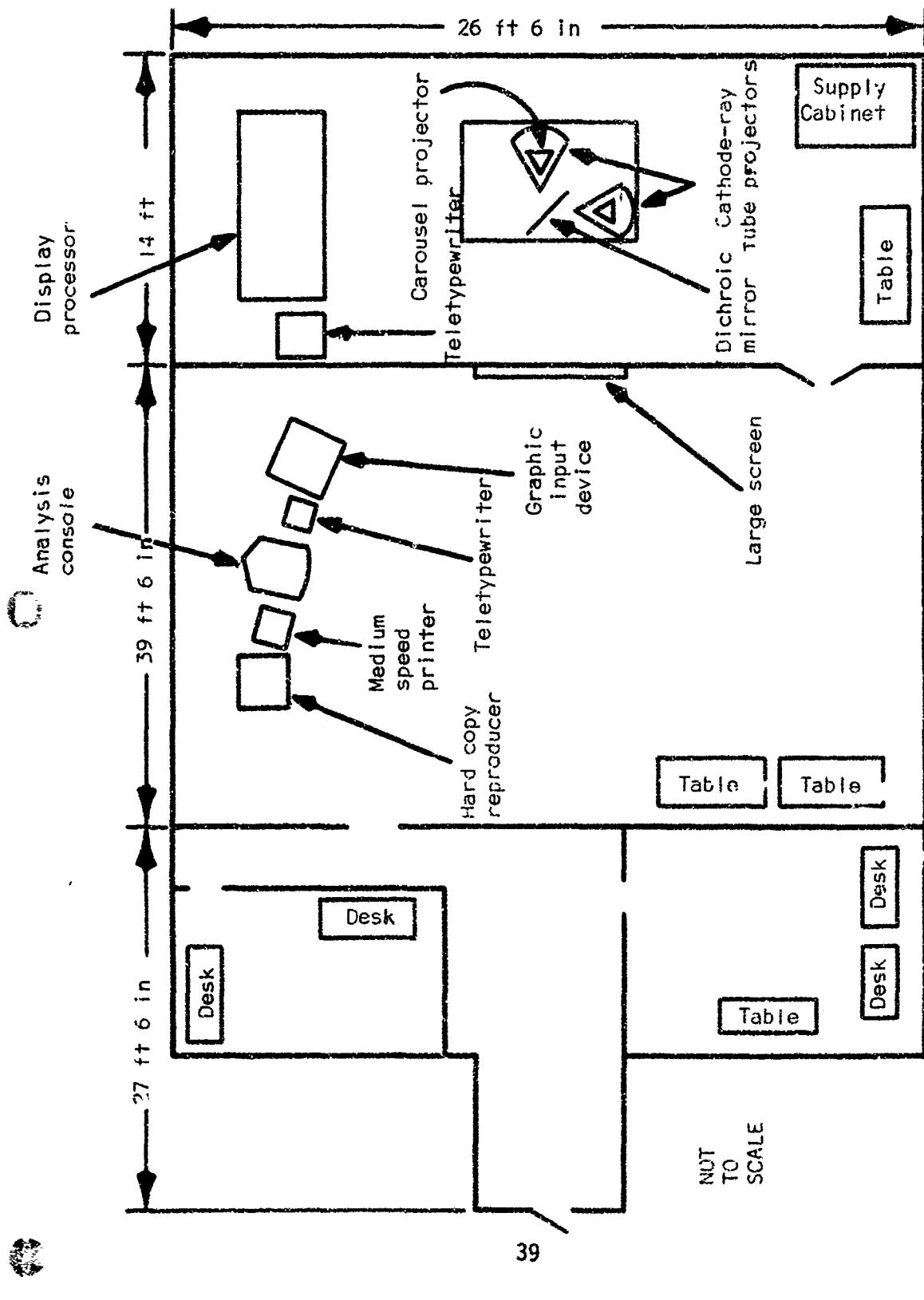


Figure 1-9. Bunker Schematic, CRT system.

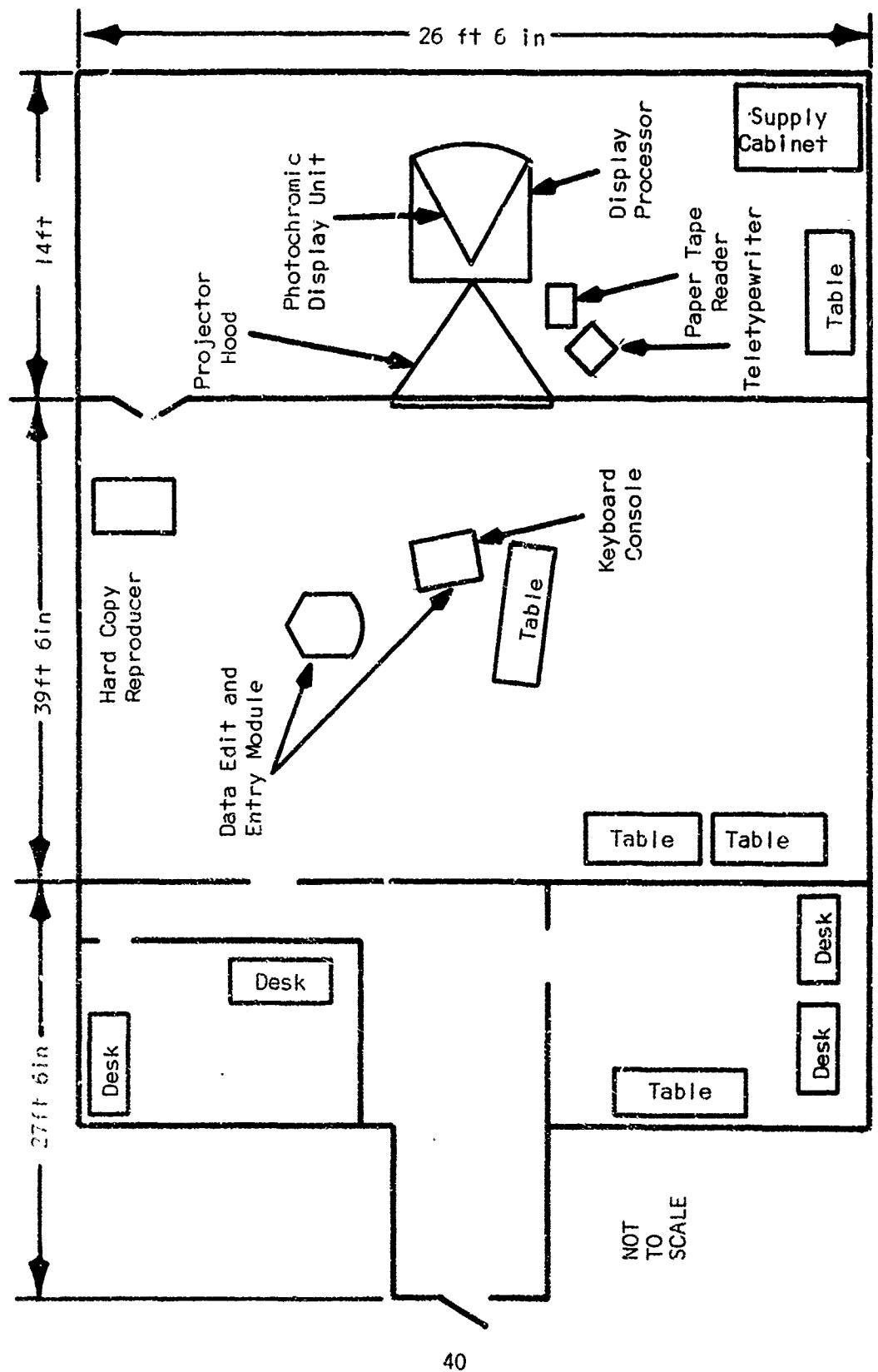


Figure 1-10. Bunker schematic, photochromic system.

required data. The questionnaire was distributed to 230 personnel who had TOC experience. A discussion of the results of both efforts is presented in the following subparagraphs. Part three, section 1, contains the reduced data on which this discussion is based.

(1) The division, brigade, and battalion TOC activities which use information displays are identified in figure 2-1.

Division	Brigade	Battalion
G2 (Operations-Plans)	S2	S2
G2 Air	S2 Intelligence Team	S2 Intelligence Team
G2 Intelligence Team (BICC)	(BICC)	(BICC)
G3 (Operations-Plans)	S3	S3
G3 Air	S3 Air	S3 Air
Fire Support Element (FSE)	Fire Support Coordination Center (FSCC)	FSCC
Airspace Control Element (ACE)	TACP	TACP
Signal Intelligence Support Element/ Electronic Warfare Element (SSE/EWE)		
Tactical Air Control Party (TACP)		

Figure 2-1. Activities that use information displays.

(2) The majority of division, brigade, and battalion TOC activities use displays for rapid access to frequently referenced information to assist in planning and coordination. Intelligence activities use displays to assist in analysis. The majority of these displays require updating at least hourly. The number of required information displays range from 4 for the division and brigade TACP to 19 for the division G3 (Operations-Plans). The situation map is the most universally required display.

(3) Map backgrounds are required for division, brigade, and battalion TOC situation displays. The level of detail found on the present standard military map is not required for many of these displays. The amount of map detail required depends on the specific purpose of the display. Since maps with lesser detail are not in the current inventory, the map meeting the requirements of most TOC users is the standard military topographic map.

(4) The preferred map scale for use in the division, brigade, and battalion TOC is 1:50,000. At the division level TOC, a secondary preference is the 1:100,000 map scale.

(5) The number of colors used for displaying dynamic data is dependent on the requirement to readily distinguish between various information categories. Survey results from division, brigade, and battalion TOC users indicate that most situation displays require three colors (usually blue for friendly, red for enemy, and black for control measures). Black is also used on a contrasting background to depict letters and numbers on TOC charts. The colors presently used to depict topographic symbols on the standard tactical map sheets, as discussed in FM 21-31, are satisfactory at all TOC levels.

(6) The brigade and battalion TOC users prefer situation displays approximately 4-feet high by 4-feet wide. Division users prefer a display approximately 4-feet high by 5-feet wide. Chart or tabular status displays are approximately 3-feet high by 3-feet wide.

(7) The number of simultaneous viewers of displays during normal operations for the division, brigade, and battalion TOC is approximately four. For formal briefings, the number of viewers depends on the echelon; up to 10 at battalion and up to 20 at brigade and division.

(8) The division, brigade, and battalion TOC's require from one to five copies of most overlays. The reproduction time required for the majority of DTOC overlays is approximately 15 minutes. Survey respondents indicate that a hard copy reproduction of approximately one-half of the essential DTOC overlays would be desirable for purposes of reference and dissemination.

b. The findings from subobjectives 1 and 2 provide input to assist in answering objective 2 of FMI16 - Evaluate proposed requirements statement under operational conditions and recommend changes as appropriate. Objective 2 is addressed in section II of this chapter. The findings pertaining to subobjective 3 are contained in section III of this chapter. Section III addresses objective 3 of FMI16 - Evaluate the suitability of candidate computer driven display technological approaches to meet proposed requirements criteria. This section assesses, by component, the performance of each of the three evaluated automated display systems in meeting the recommended system technical requirements formulated in section II.

Section II - Automated Display System Requirements

2-2. Introduction.

a. This section addresses objective 2 of FMI16 - Evaluate proposed requirements statement under operational conditions and recommend changes as appropriate. The display requirements that were evaluated are listed in the Department of the Army (DA) approved MN for TOS dated November 1972. The two components described by the MN for TOS which relate to the display of tactical data are the group display device (GDD) and the analysis console (AC).

b. Organization of the remaining sections of this chapter was influenced by the following factors:

(1) Experimentation with three different display systems was conducted over a period of 12 months. The experimentation produced data which answered questions in specific areas and also brought to light other areas in which further study and/or experimentation is worthwhile. New automated display system requirements gradually evolved as a result of the experimentation.

(2) A listing of specific system requirements is best preceded by a narrative discussion which not only outlines the requirements but also provides the background, rationale, and philosophy underlying the requirements.

(3) The TOS MN requirements are not listed in an order that is readily addressable. Requirements pertaining to a specific area or function are not grouped together but are found randomly throughout the listing.

(4) Requirements for automated display systems are more appropriately presented by grouping them into user-oriented functional categories. The five categories addressed in this report are viewability of displayed data; placement accuracy and display completeness; map backgrounds; timeliness and ease of use; and reliability, availability, and maintainability. This organization assists in the statement of requirements not listed in the MN for TOS but identified as a result of the experimentation.

c. This section is organized into four areas:

(1) Paragraph 2-3 describes the major display system findings which evolved as a result of experimentation during FMI16. It provides an overall frame of reference for the remaining parts of the section.

(2) Paragraph 2-4 discusses, in narrative form, the requirements for an automated display system. The requirements are grouped into the five functional categories mentioned in subparagraph b(4) above.

(3) Paragraph 2-5 addresses each GDD and AC requirement in the order that they are listed in the MN for TOS.

(4) Paragraph 2-6 extracts from paragraphs 2-3 and 2-4 and states, for the system and system components, the specific technical requirements for an automated display system. The rationale for each requirement is also stated. These requirements are used in section III of this chapter to assess system performance.

d. The reorganization of the requirements into the five functional categories precludes addressing each subobjective of objective 2 directly. However, all subobjectives are addressed. Reorganization into the five functional categories merely presents the requirements in a more meaningful and useful format.

e. Two assumptions stated in the detailed plan of test guided the formulation of the requirements stated in this chapter:

(1) The echelon at which TOS will initially be employed is the division. The stated requirements are for a display system envisioned for use in a division TOC. Display system requirements for higher or lower echelons, if it is determined that display systems are required at these echelons, will require analysis and modification of the division requirements to make them applicable to these echelons.

(2) The primary users of TOS and the display systems associated with TOS are the commander and the operations and intelligence staffs in a division TOC. The stated display requirements are directed to these primary users. However, it is recognized that there are other potential users of display systems in the division. If a display system is needed for one or more of these potential users, the stated requirements may need modification to fit the specific user.

f. The results presented in the remainder of this chapter are based on knowledge developed through a number of contributing factors which include an 18-month period of planning and hands-on experimentation with three automated display systems; visits to vendors and other services which had display systems; attendance at conferences, seminars, and classes on display systems; analysis of manual display requirements; discussions of automated display requirements with personnel from combat units who operated the systems during the experimentation; and discussions with special evaluators from agencies outside of MASSTER. These agencies included Project Management Office, Army Tactical Data Systems; Computer Systems Command; Army Research Institute; Defense Mapping Agency; United States Army Materiel Command-Electronics Command; Engineer Topographic Laboratory; and Combined Arms Combat Developments Activity.

2-3. Automated Display Systems - General. The subparagraphs that follow present general findings for automated display systems envisioned for use in Army Division TOC's. Automated display systems must integrate hardware, software, and the user for whom the software and hardware are designed. It is the user and his mission accomplishment which must be supported. Findings which relate to each of these three interdependent system elements are discussed below:

a. Hardware. The MN for TOS identifies the GDD and the AC as the devices required for display and manipulation of data in a TOC. The GDD and the AC are controlled by the TOS central computer. A brief description of the role of each device is provided below. A discussion of the experimentation findings relating to the hardware components of an automated display system follows the description.

(1) The GDD has a large screen (4 by 4 foot minimum; 6 by 6 foot maximum) and is the primary operations and planning display device. The GDD portrays units, locations, boundaries, and zones or areas on a tactical map background. The GDD includes the overlay reproducer as a subcomponent to provide transparent overlays from displays on the GDD suitable for use with standard Army maps.

(2) The AC provides the man-machine interface between the user and the system data base. It operates as a graphical display similar to the GDD and as an alphanumeric input-output device. The MN for TOS does not specify a capability for transfer of displays between the AC and the GDD.

(3) Experimentation findings show two basic hardware components are required for any automated display system used in a division TOC. The first is a local display processor which allows for the receipt, storage, retrieval, display, and manipulation of data. The processor also controls the operation of the hardware components of the display system. The functions that the processor must perform dictate that it be separate from the TOS central computer and that it be dedicated solely to the operation of the display system. It is inefficient and impractical to require the TOS central computer to do the display data processing as well as control all the devices of the system. The problem is compounded when a number of display systems are linked to TOS, thus multiplying the total number of devices to be controlled. The separate display processor is not only more user responsive, but it also acts as the single point of contact for interaction between TOS and the display system. The display processor also facilitates "stand-alone" operation of the system and provides a built-in continuity of operations (CONOPS) benefit.

(4) The second basic hardware component of an automated display system is the interactive graphic display console. This component is

the primary user device for the display of, and interaction with, computer stored data. The console features which make this possible are a display surface dedicated to the presentation of displays for a specific user; the controls, such as a keyboard, joystick, and light pen with which the user can recall, create, modify, or delete displays; and a positive visual feedback on the display surface which allows the user to monitor display manipulation.

(5) An automated display system from a hardware point of view contains basic components (a display processor and one or more interactive graphic display consoles) and other hardware components (peripheral devices) as required to meet particular user needs. Figure 2-2 shows how hardware components could be configured for a display system supporting one user, the division G3. To support an additional user such as the G2, the figure would also show dedicated interactive graphic display consoles for the G2. Other peripheral devices that the G2 requires would be added if sharing the use of a peripheral device (such as the printer for the receipt of messages or the map overlay input device for inputting overlays to the system) is unsatisfactory.

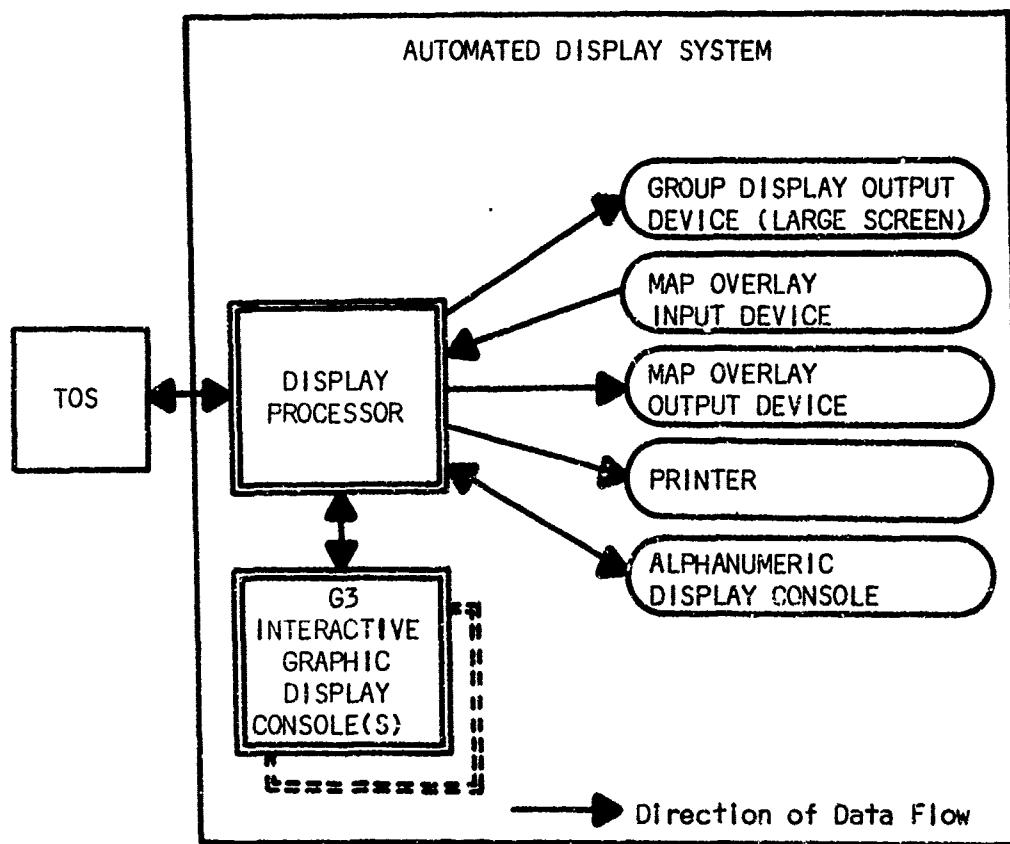


Figure 2-2. Type hardware configuration.

(6) In figure 2-2 the interactive graphic display consoles are the primary display devices. The group display output device (large screen) is shown as a peripheral output device to be included in the configuration only when anticipated usage justifies its inclusion. Control of displays on the large screen is accomplished through an interactive graphic display console. Displays to be viewed on the large screen are first composed on the interactive graphic display console, then transferred to the large screen. This role of the group display output device was determined from data provided by users and special evaluators throughout the experimentation period and was initially identified from two observations during the CPX portion of the experimentation.

(a) During the CPX, the primary use of the large screen on both the scribe and CRT systems was for briefings. Although situation displays were portrayed on the large screens when they were not being used for briefings, the analysis console (editing console in the scribe system) was where the attention of key players was focused, where displays were manipulated, and where player reception of, and reaction to, incoming data occurred.

(b) The G2 and G3 sections formed a player group and used one system, while another player group (the BICC) used the other system. Since each system had only one usable console (the scribe system had a second console but its use interfered with the first) and one large screen, the G2 and G3 players were forced to share these devices. The majority of player comments indicated that the console display, although smaller, was satisfactory and was preferred over the large screen display mainly because the player could "do" more at the console because it was interactive. The comments also overwhelmingly favored separate, dedicated consoles for the G2 and G3.

(7) The group display output device was not found to be an essential part of division level tactical display systems. However, experimentation findings do not nullify it as a potentially useful component of an automated display system. When current displays on a console need to be viewed by a large number of people during the course of a briefing, a device which provides for rapid display transfer and has a screen larger than that available on the console may be justified. When the device is not being used for briefings, it can be used to display the current situation for the benefit of all TOC personnel and visitors from other headquarters.

(8) The requirement for a group display output device for a display system should be based on a cost-benefit analysis. The expected advantages must be considered against the additional volume, weight, and complexity imposed on the system. In each of the three systems evaluated, the large screen display components constituted a major part of the system's total volume and weight. Since the display system is

expected to be housed in a vehicular-mounted shelter, volume and weight considerations will impact upon the number of shelters required and the overall system mobility.

(9) The experimentation findings relating to the roles of the interactive graphic display console and the group display output device indicate a shift in emphasis from visualizing the large screen as the central, dominant component of an automated display system to stressing that the processor and the interactive console form the heart of the display system.

b. Software. The key to user acceptance of an automated display system is proper definition of user requirements. Meeting the requirements is heavily software dependent. Suitable hardware is available or can be developed, but what the hardware is able to do for the user is largely a function of the software (i.e., the routines that perform the display functions which aid the user in accomplishing his mission).

(1) After user requirements have been defined, software should receive first priority in the development of an automated display system. This does not mean that initial emphasis is to be placed on developing detailed logic flow diagrams. Rather, detailed answers should be obtained for the question: "What procedures should be designed to permit the user to meet his requirements with maximum ease?". The answers should define the software required. The software will provide vital guidance concerning hardware type and configuration.

(2) This approach defines the user's needs and identifies the software required to meet these needs before the hardware is procured. The logic of this approach is better than the common practice of buying the hardware and then designing software to fit the hardware. Additionally, software comprises the bulk of system development cost, and therefore, should receive priority.

c. User. The individual who will actually use the equipment in the field is the most important element in successful design of an automated system. The question asked in subparagraph b(1) above can best be answered by this individual. His comments must be actively solicited by the hardware and software designers in all stages of system development. Violation of this principle could result in the fielding of a system which may be rejected in favor of the current manual operation because it does not do what is wanted, is too complicated to operate, or is simply too cumbersome.

(1) An automated display system must satisfy different users in a TOC. The division G2 and G3 are considered separate users since they have different information requirements. For example, the G3 may be concerned with monitoring the maneuver of friendly units of battalion

size and larger within the division area of operations. The G2 may be interested in an area different from that of the G3 and may require the display of particular enemy units and weapons located in his area of interest. User requirements will dictate the hardware configuration of an automated display system.

(2) Automated display systems have the potential for easing the user's transition from manual to automated operations, because they present displays much like the user now employs. The display of data by an automated display system is preferable from a user standpoint to receiving the same data as computer printed copy for subsequent map posting.

(3) The following quote from Parslow, Prowse, and Green¹ is an excellent discussion of the role of an automated display system and particularly the interactive graphic display console. The application characteristics cited at the end of the quote are *exactly* those for an automated display system in a tactical operations center!

"Graphic data processing provides a common language of graphics and alphanumerics between the man and the computer. A man normally thinks in terms of sketches, drawings, graphs, letters, characters, and numbers. A computer operates in terms of bits, bytes, and registers. This makes it difficult for the man to communicate with the computer. In the past, the burden has been on the man; namely, he has had to convert all of his ideas and thoughts to letters, numbers, and a few special characters. The computer, in turn, conversed back with the man in the same medium. With the advent of graphic data processing, the man can work in the medium he understands best; the computer can continue to work in the medium it understands best, with the graphic display console acting as an interpreter between the two. This new dimension in man/machine communication has proved to be of value in applications where: Graphic representation is of assistance in the performance of the application, or Rapid turn-around time is required, or Human imagination, judgement, or experience is required in the solution of the problem."

2-4. Narrative Discussion: Automated Display System Requirements.

a. General.

(1) This paragraph discusses requirements for the different components of an automated display system. The intent is to state the

¹Computer Graphics, R. D. Parslow, R. W. Prowse, R. Elliot Green, Plenum Press, 1969.

requirement as the end result that should be provided to the user by the system. Therefore, the requirements are discussed from the user viewpoint and are display technique independent.

(2) The requirements, as discussed, are not system specifications. Rather, they represent user specified *guidelines* for those display functions that an automated display system should perform. They should be used as the basis for definition of system specifications.

(3) The requirements are grouped into five functional categories: Viewability of displayed data; placement accuracy and display completeness; map backgrounds; timeliness and ease of use; and reliability, availability, and maintainability.

(4) Requirements are stated for an alphanumeric display console. It should be noted that none of the three evaluated systems contained this device. The necessity for the device arose from the observation that a substantial amount of strictly alphanumeric data is routinely input, displayed, or transmitted by users of an automated display system. The input of data into the system's data base becomes particularly critical if the system operates in a "stand-alone" mode away from TOS and data must be input by the display system user. Although the interactive graphic console has the capability, its use to routinely input, display, or transmit alphanumeric data would seriously detract from its primary function of presenting graphical situation displays. While using the interactive graphic display console to input, display, or transmit alphanumeric data, the user is unable to view and interact with graphical situation data on the console. Thus, the full capabilities of the interactive console are not exercised. During the CPX, a DEVTOs alphanumeric display console called the message input and output device (MIOD) was used by the automated display system users to query the DEVTOs data base.

b. Viewability of displayed data. A primary requirement for any display is that it be viewable. Viewability is defined as the legibility of individual symbols and the overall comprehensibility of a tactical display. Displays must be both legible and comprehensible to be of value. The viewability requirements for the devices of an automated display system are listed below:

(1) Interactive graphic display console (individual display).

(a) The symbols required to be displayed on the console are the 64-character American Standard Code for Information Interchange (ASCII) set; selected FM 21-30 symbols; symbology added to the symbol generator by the user; circles; ellipses; and freehand graphics. The symbols which are recommended to be a part of the permanent symbol generator are listed in subparagraph e below. Many of the symbols in FM 21-30 are not used frequently enough to justify character generation on a full-time basis. The additional hardware and software that would be required for

full-time character generation of all symbols in FM 21-30 is prohibitive. However, the system must allow the user to easily add a number of additional symbols to the character generator on an "as-required" basis. This requirement is discussed in subparagraph e below. The freehand graphic symbols found in FM 21-30 such as the symbols for objectives and axes of advance will require approximation by variable length line segments, since they do not lend themselves to character generation because of their variable size, shape, and direction.

(b) A minimum of three colors is required. Three colors allow distinction of friendly, enemy, and control measure symbols. Distinction of friendly symbols from enemy symbols is possible on a one color display by means of shape coding. However, the enhanced ability of the user to readily distinguish between color coded enemy and friendly symbols at a glance is required to preclude delay in their discrimination. Use of a third color to depict control measures further enhances the user's ability to distinguish between the three types of information. Four to six colors are desirable. The extra colors allow the highlighting of selected symbols or the color coding of particular categories of information. The main factor to consider in selecting colors is their legibility. Red and blue are traditional but not absolutely necessary. Symbol color selection must be based upon obtaining a high degree of contrast in relation to the colors used for the map backgrounds. A discussion of map background colors can be found in subparagraph d below.

(c) The symbology should be fully legible to the operator under normal office lighting (70 foot-candles at desk top level). This reduces the eyestrain and fatigue of individuals working in the immediate area. Full legibility of the symbology with desk lamps at each work space and no overhead lights is marginally acceptable. Full legibility is defined as easy identification by the console operator of any symbol contained in a tactical situation display.

(d) The console must be designed with one optimum symbol size in mind. However, symbol size should be under user control. The operator should be able to increase or decrease (within limits) the size of the symbols. Whenever a change in size is made, all symbols in the display change. It is desired that the size selection be continuous but discrete sizes are acceptable as long as a number of sizes are provided. The selection of an optimum symbol size should be based upon obtaining symbols that are fully legible to the console operator under the required lighting conditions. However, the symbols must be small enough to present a tactical situation display that is not unduly cluttered. This hinges, in part, on the size of the console screen. The screen must be large enough to depict a tactical situation, but it must not be so large that it causes the operator undue eye and head movement. The greatest number of military unit symbols required to be displayed at one time on a division tactical display is estimated as 75. The average number is estimated as 40.

(e) Operator eye and head movement are influenced by two factors: screen size and the distance of the operator from the screen. It is assumed that the screen will be located within arm's reach of the operator. This seems a reasonable assumption based on the fact that most individual display console screens in existence, regardless of application, are located less than an arm's length from the operator.

(f) The displayed symbology must have no discernible flicker. The console operator must be able to control the brightness of the dynamic symbology and the brightness of the background. Overall brightness control allows adjustment to suit the ambient light environment. The brightness of each dynamic symbol color and of each map feature color should also be under user control. This allows the operator to subdue categories of information which at a particular moment are not of significant interest or which detract from other information.

(g) Fully automatic declutter (offset), upon initial display, of any symbol for a military unit, spot report, sensor location, etc., is required. Control measures are not declutterable. Declutter lines must be directly attached to the decluttered symbol. Newly entered symbols should be displayed so that they do not overlap existing symbols, but they should be displayed as close to their true position as possible. Symbols already in the display should not be readjusted, since the operator's perspective could be affected. The operator must have the ability, however, to declutter symbols manually. He should also have the ability to cause a complete, automatic re-declutter of the display when desired. This re-declutter relocates all symbols based upon the criteria of the shortest possible declutter lines and no symbol overlap. Each symbol should be considered equally in the re-declutter. Priority of entry should have no effect.

(h) Before automatically decluttering a newly input military unit headquarters symbol, the system must determine if the new symbol is co-located with another military unit headquarters in the display. If so, the new symbol and the co-located symbol(s) must be "stacked" (they should be placed on one staff). The stack should be automatically decluttered if necessary.

(2) Group display output device.

(a) The symbols required to be displayed on the group display are the same as those for the console: the 64-character ASCII set; selected FM 21-30 symbols; symbology added to the symbol generator by the user: circles; ellipses; and freehand graphics. The symbol style and proportion must match those used on the console. This is to prevent identical displays on the two devices from appearing different when, in fact, they are not. All displays on the console should be displayable on the

group display. The group display scene must appear to be an enlargement of the console display scene. However, this does not mean that the group display must always show the same display scene as the console. The group display must be able to show display scenes independent of those shown concurrently on the consoles.

(b) The color requirement for the group display is identical to that for the console. However, technological limitations which prevent the obtainment of an equal number of colors on both devices should not limit the number used on the unaffected device. For example, cost and other considerations may cause three or more colors on the group display to be impractical, but a four-color display on the console may be no more costly than a two-color display. In this case, the console display should not be limited to two colors. However, both devices should use the same colors to depict enemy symbols and friendly symbols.

(c) The group display should be fully legible under normal office lighting (70 foot-candles at desk top level). This requirement could be relaxed to as low as 30 foot-candles since the group display is primarily used for briefings. Thirty foot-candles is the amount of light required for note taking. Full legibility is defined as easy identification by any viewer in an audience of 20 people of every symbol in a tactical situation display.

(d) Like the console, the group display must be designed with one optimum symbol size in mind, and this size should be variable by the operator. The selected size should be independent of the size selected on the console. However, when a display is initially transferred to the group display, the operator should have the option of allowing it to appear in a size proportioned to the size selected on the console. The optimum symbol size should be small enough to present a tactical situation display that is not unduly cluttered. Symbol clutter is dependent upon symbol size, number of symbols, and screen size. The group display must be large enough to comprehensively present a tactical situation display to an audience of at least 20 people.

(e) The displayed symbology must have no discernible flicker. The brightness of each dynamic symbol color and of each map feature color should be under user control. This allows the operator to subdue categories of information which at a particular moment are not of significance or which detract from other information. It also allows the operator to adjust for the ambient light environment. The user must, as a minimum, be able to vary the overall brightness of the dynamic symbology and the overall brightness of the map background.

(f) Symbol declutter should pose no problem for the group display, since all displays shown on this device are first edited on the console.

(3) Map overlay output device.

(a) The symbols required for output on this device are the same as for the console: the 64-character ASCII set; selected FM 21-30 symbols; symbology added to the symbol generator by the user; circles; ellipses; and freshand graphics. The symbol style and proportion must match those used on the console. This is to prevent an overlay from appearing different from the console display when, in fact, it is not. All display scenes on the console should be reproducible in multiple copy on the hard copier.

(b) The three color requirement for the console is desired on the map overlay output device.

(c) The overlay must be capable of being output on transparent material. This allows placement of the resulting overlay on a standard military topographic paper map where it will normally be used. The contrast of the symbols against the standard military topographic paper map is an important consideration. This requirement is not intended to exclude output on other material such as paper.

(d) The symbology when shown against a standard military topographic paper map must be fully legible in as little as 30 foot-candles of ambient light, since low ambient light levels may exist where the overlays will be used.

(e) Only one symbol size is required. The size should be selected so that the symbols are fully legible to the individuals working with a map board under 30 foot-candles of light. However, the symbols must be small enough to present a tactical situation display that is not unduly cluttered. The map area of coverage must be identical to that of the console. However, the physical size of the output will correspond on a 1 to 1 ratio with the standard military topographic paper map (i.e., a 50-kilometer square area of coverage on an output scale of 1:50,000 will measure 1 meter by 1 meter on the map overlay output). This allows a standard topographic paper map to be used as a background.

(4) Printer.

(a) The characters in the 64-character ASCII set are the only symbols required for output by the printer.

(b) The size, style, and proportion of the characters must be fully legible to the user when they are viewed as lines of print in as little as 30 foot-candles of ambient light.

(5) Alphanumeric display console.

(a) The symbols required to be displayed on the console are the 64-character ASCII set. Message formats and tabular chart outlines, either completed or to be completed, will also be displayed.

(b) Two colors are desirable. The second color allows message format and tabular chart outlines to be readily distinguished from the dynamic data.

(c) Screen size is affected by the distance of the operator from the screen, character size, and number of characters to be displayed. The operator will be within arm's reach of the screen. The screen size should be designed to display approximately 1,500 characters. This is the number of characters specified for the M1OD in the TOS MN document. Only one character size is required.

(d) Displays on the console must be fully legible under normal office lighting (70 foot-candles at desk top level). This reduces the eyestrain and fatigue of individuals working in the immediate area and is well within the capability of available alphanumeric display consoles. Full legibility is defined as easy identification by the console operator of any symbol in the display. The operator must be able to adjust the brightness of the display to suit the ambient light environment by means of a brightness control located on the console.

c. Placement accuracy and display completeness.

(1) When a user views a displayed tactical situation, the data items defining the tactical situation must be accurately positioned against the appropriate map background. In addition, the display must be complete (i.e., all data items which belong in the area of coverage, if they are contained in an information category selected for display, must be present on the display).

(2) Placement accuracy is defined as the ability of the system to position a data item at a specified location on a map background. Current manual procedures for plotting symbols against the 1:50,000 scale standard military map have an inherent plotting accuracy. The average individual updating a map in the TOC will, with few exceptions, position a given symbol within 100 meters of its specified map location. Most display users in the operations and intelligence sections of the TOC are concerned with the effect that symbol placement accuracy has on the evaluation of the positional relationships of the displayed symbols. While some users may require greater accuracy, the inherent accuracy of manual map posting is acceptable to most users in the TOC.

(3) Data items superimposed against a map background on the interactive graphic display console and on the group display must appear to be no more than 100 meters from the specified map location. This 100-meter limit applies for any method of data item location: keyboard coordinate entry, coordinates transmitted from an outside ADP source, points transmitted from the map overlay input device, or direct entry by pointing to the location on the console. The 100-meter limit also applies regardless of the size of the area of coverage being viewed. For example, if a data item is perceived to be within 100 meters of its specified map location on a 50-kilometer by 50-kilometer area, it should appear to remain within 100 meters when a 10-kilometer by 10-kilometer blowup of the data item's location is displayed and vice versa.

(4) The accuracy requirements discussed in (2) and (3) above refer to what is expected when the system *displays* dynamic symbology against a map background. A separate requirement is the accuracy returned when the system is queried as to the Universal Transverse Mercator (UTM) coordinates of a displayed data item. The system accuracy for all data item locations entered as specific UTM coordinates (i.e., keyboard entry and coordinates from an outside ADP source) must be *exact*. If a data item location is entered as a 4-, 6-, or 8-digit coordinate, the system, when queried, must return the coordinate exactly as entered. The coordinate provided in reply to a query for data items entered by pointing and for locations entered through the map overlay input device must be no more than 100 meters from the apparent map location of the data item.

(5) Data item placement accuracy requirements also affect the map overlay input device and the map overlay output device. The map background used on the map overlay input device must be registered in such a manner that a data item entered as a series of points from either the overlay or the map will, if displayed on the console or group display, have the points *displayed* no more than 100 meters from the points entered through the device. The overlays produced by the map overlay output device will be used in conjunction with standard military topographic maps. When the overlay is placed over these maps, the data items must be no more than 100 meters from the symbol locations used to input the overlay to the system.

(6) Display completeness is defined as the display of *all* data items in the currently selected information categories which have coordinate locations within the selected map background area of coverage.

(7) Data items are located either with single points (e.g., a military unit or a coordinating point) or with multiple points (e.g., a unit boundary or a trench line). Data items located with single points

must be completely displayed if the point is inside the selected area of coverage. This may require the automatic decluttering of the data item to ensure that the entire item appears in the area of coverage such as when a military unit location is at the top edge of the background.

(8) If any part of a multiple-point data item is in the selected area of coverage, that part within the area of coverage must be displayed. The part to be displayed must include all points of the data item up to and including those at the intersection of the item with an edge (or edges) of the map background.

(9) Incoming messages from outside ADP sources (e.g., TOS) will affect individual military symbol completeness when the message defines a military unit whose branch duty symbol is not in the system's permanent branch symbol library. To ensure that the data item is complete, the system must display at least the first four alphanumeric characters of the branch duty designation (from the incoming message) inside the rectangle where the branch duty symbol normally appears. The user may then replace the alphanumeric characters with a previously created symbol or with a symbol which he creates.

d. Map backgrounds.

(1) General.

(a) A map background is an essential part of any tactical situation display. The display of the situation is relatively useless unless the symbology is superimposed upon a map background, thereby orienting the symbology to the terrain. The majority of symbols on a display are input as single map locations or as a series of map locations, normally UTM grid coordinates (e.g., "HQ, 53d Mech Division is at PL 235692"; "the left boundary of the 1st Brigade extends from XT 127608 to XT 119672").

(b) Map backgrounds have three general uses in a TOC:

1. Comprehension of the overall situation. For this purpose, the user is located at a distance far enough from the display to view the entire area of coverage without excessive eye and head movement. He is not interested in being able to read all detail on the standard military topographic map but uses the map to provide general orientation for the superimposed symbology. Orientation is accomplished by relating the symbology to significant map features such as roads and highways, towns, hill masses, rivers, and perhaps major grid lines. The 1:50,000 scale standard military topographic map normally used in TOC's is not ideally suited for this use, because of the large amount of detail on it. A common solution is the annotating and/or highlighting of the significant map features with grease pencils or colored ink pens to provide easy legibility at a distance.

2 More detailed inspection of the terrain at or in the vicinity of a superimposed symbol or symbols. In this case the user is interested in a more exact relationship of the symbols to the terrain. He is for the moment not interested in the entire area of coverage but moves closer to the map and "zooms in" on the small portion of the overall area where the symbols of interest are displayed. He moves as close as is necessary to view the amount of map detail he requires, which may well be all map detail.

3 Terrain analysis without superimposed symbology. For example, when selecting the best terrain upon which to establish a defense or when planning a route of movement, the user wants to view the map background with no superimposed dynamic symbology. Depending upon the user's mission, he may require varying degrees of map detail. In one instance, the primary and secondary road network may be all that he needs to plan a route of movement. In another instance, he may also want to study the contour lines to obtain a detailed mental picture of the shape of the terrain. This use of a map is prevalent in the planning functions of a TOC.

(c) Each of the three general uses of background maps described above has its own peculiar requirements for area of map coverage and level of terrain detail. Not only do these requirements differ from echelon to echelon, but they also vary among users at each echelon. For example, the division G3 monitoring the friendly situation may require a background showing only major rivers, roads, towns, and grid lines, while a user in the G3 plans section may require a background with all the detail of the 1:50,000 scale standard military topographic map in order to determine and compare courses of action for an upcoming operation.

(d) An automated display system must be capable of displaying map backgrounds for the three uses described above. This implies that the system's map background display capability must meet differing user requirements for area of coverage and level of terrain detail. The obvious problem is the attainment of map detail legibility on the relatively small console screen. It is not realistic, nor desirable, to expect the legibility found on paper maps from the overall situation maps which will be displayed on the console. First of all, even if technology could faithfully preserve all detail in the console display, the ability of the human eye to resolve fine detail which has been greatly reduced in size becomes the constraining limitation. Secondly, it was noted in subparagraph (b)I above that a user viewing the entire area of coverage focuses only on significant map features, and therefore does not require all available map detail. For this type of viewing, a map background specifically highlighting those map features significant to the user (analogous to the map annotating and/or highlighting currently

done in the TOC) is preferable to the display of the standard topographic military map. The console, however, has the potential for meeting the two uses which require a more detailed map inspection, because it can be the instrument to allow the user to "zoom in" on a smaller portion of the overall area of coverage. Thus, if a console map display of a portion of the overall area has a display scale of 1:50,000 (i.e., 2 centimeters on the screen represents 1 kilometer) or larger, the legibility of the displayed map detail would ideally be no less than that of the standard military topographic map.

(e) If the map background displayed on the console does not have the degree of legibility desired by the user, then a map board with a hard copy map could be placed near the console for those instances when the user requires legibility of detail (for portions of the overall area) not attainable on the console screen. This map board could also assist in continuity of operations (CONOPS), where system degradation or TOC displacement may preclude continued presentation of displayed data. In these instances, the user may be forced to revert to other procedures which include the temporary use of manual displays.

(f) The larger screen of the group display output device offers the potential advantages of legibility at least equal to the standard military topographic map. However, the primary use of the device is for group viewing. Use of the device by individual users for the viewing of map backgrounds with a high level of detail might interfere with this primary use.

(2) Interactive graphic display console (individual display).

(a) Map backgrounds based on the UTM grid system will normally be displayed on the console. However, the console should be able to accommodate other military grid systems. The UTM grid system requires that the console be able to display areas of coverage which include the junction of two or more map sheets and the junction of two or more 100,000-meter grid zones.

(b) The console must be able to display an area of coverage large enough to permit superimposing dynamic symbology for most user tactical situation displays. User data indicates that an area at least 50 kilometers by 50 kilometers is required for an *overall* situation display of an armored or mechanized division. The console screen size must be designed to provide this area of coverage. It is assumed that the screen is within easy arm's reach of the operator. The operator must be able to view the entire screen image area from this distance without undue eye and head movement.

(c) When the user changes the area of coverage displayed on the screen, user specified dynamic symbology in the new area of coverage must be automatically displayed on the new area at the appropriate map locations. This requirement applies if the new area is a magnification of a small portion of the old area, if it includes all or a portion of the old area, or if it does not include any portion of the old area.

(d) Map backgrounds displayed on the console screen must be fully legible under the dynamic symbology ambient light requirement. Full legibility is defined as the ability of the operator to easily identify each and every item of map data displayed. A data item which is not legible is of no informational value. To enhance legibility, there should be a high degree of contrast between colors used for the dynamic symbology and the colors which represent map data. Colors used on current hard copy maps are red, green, blue, brown, and black. This combination may not be the best for an automated display system. As was the case for dynamic symbology, selection of colors to represent map data on a display should be based primarily on providing maximum legibility and should not be based on tradition.

(e) The console operator should be able to vary the brightness of the colors used for specific map features (e.g., roads, vegetation, rivers). He must, as a minimum, be able to vary the brightness of the entire map background without altering the brightness of the dynamic symbology. This capability, combined with the ability to vary the intensity of dynamic symbology, allows the user to concentrate on dynamic symbology or map data as desired.

(f) The console must be able to display backgrounds which meet the user's requirements for varying area of coverage and selective level of map detail. Ideally, the user should be able to specify the desired area of coverage by providing the system with the coordinates of any two diagonal corner points. The system then automatically displays the desired area on the full screen image area. The operator must have the option to number or otherwise identify the area for convenient recall. Thus, the area can be tailored for the particular situation, whether it be 1 kilometer by 1 kilometer or 50 kilometers by 50 kilometers. Ideally, the user should also be able to tailor the level of map detail to the situation by being able to display specific map features (grid lines, roads, contours, rivers, etc.) individually, or in combination, for the defined area of coverage. For each specific map feature, the user should be able to select more or less detail (e.g., grid lines 1, 5, or 10 kilometers apart; primary roads only or primary and secondary roads; contour intervals of 100, 200, or 500 meters).

(g) A study should be conducted to determine the techniques that could be employed to provide the solution to the requirement for tailoring of both the area of coverage and the level of map detail. Ultimately, the Army will be responsible for providing the map data in the form to

be used for the map background display technique selected. Consequently, the feasibility, advantages, disadvantages, and costs of all available map background display techniques should be the subject of a study.

1 One technique which may have potential is the definition of map data in digital form. It is recognized that problems are involved in the conversion of hard copy map data (particularly contours) to digital data and in the storage of this data. However, map data in digital form is directly processable for display by an automated display system and, more importantly, can be selectively retrieved by map feature or features (e.g., grid lines, roads, contours, rivers) for a selectively defined area.

2 Another technique which could permit selectively variable area of coverage is that which uses an optical system to focus on a specified subarea of a very large area. The optical scanner can be controlled to move in the proper horizontal and vertical directions to the center of the desired area of coverage, then "zoom in" or "zoom out" as necessary to project the correct area size on the console screen. A variation of this technique is the use of a television camera to perform the function of the optical scanner.

3 A state-of-the-art technique which can be employed to display map data is the use of discrete on-line backgrounds, selectively retrievable, which contain variation in both area of coverage and level of map detail. This is not the optimum solution but may have to be accepted until technology permits attainment of the ideal described earlier. If this technique is employed, the following requirements apply:

a The available backgrounds must be on-line and retrievable within 15 seconds. The capability to retrieve and display a background within 5 seconds is highly desirable. Fifteen seconds is the maximum time that a user can be expected to wait without inconvenience for the retrieval of a background. The user must also be able to add to or delete from the number of available backgrounds.

b Registration of a new background (i.e., defining for the system the limits of the area) must require the operator to only point at and input the UTM coordinates of any two grid intersections diagonally located in relation to each other. The background must not have to be exactly horizontal, vertical, or centered. Once registered, the background must be available for display without re-registration each time it is retrieved.

c Backgrounds to be used for display of the overall division situation must have an area of coverage no less than 50 kilometers by 50 kilometers. Maps for this use do not require all map detail. However, the map data must be enhanced or highlighted, and letters and numbers

may have to be larger than those found on standard military topographic maps in order to provide full legibility. Backgrounds with selected combinations of map detail are required. Overlap must be provided to allow for continuity of background area of coverage.

d. Backgrounds which magnify smaller portions of the 50-kilometer by 50-kilometer backgrounds must be provided. A sufficient number (four to nine may be sufficient depending upon the size of the console screen) of blowups should be available such that the composite area of each 50-kilometer by 50-kilometer background can be shown in magnified form. The blowups need not overlap but must contain no less detail than that found on the 1:50,000 scale standard military topographic map, and, when displayed, must be fully legible. The blowups provide the high level of map detail necessary for a more detailed inspection of the map background data either with or without superimposed symbology.

e. A study should be conducted to determine a means for providing overlap of background areas, the levels of map detail required, and the number of smaller areas required to provide adequate magnification of each 50-kilometer by 50-kilometer area. The findings pertaining to the adequacy of the map background technique used by each system (section III) point to the need for this study.

(3) Group display output device.

(a) The tactical situation displays on the group display output device are intended primarily for viewing by a number of persons. The audience size will vary, but user data indicates that viewers in a division TOC normally will not exceed 20.

(b) The envisioned use of the group display output device presents unique requirements pertaining to screen size, legibility of map data, and background level of detail. With the exception of these requirements, which are discussed in the following paragraphs, all map background requirements stated for the interactive graphic display console apply equally to the group display output device.

(c) The screen of the group display must be large enough to comprehensively present a division tactical situation display to an audience of 20 people and must provide map background coverage for an area no less than 50 kilometers by 50 kilometers. Map backgrounds on the group display should be displayed independent of the backgrounds on the console. This permits a map area to remain on the group display even though different map areas are shown on the controlling consoles. The map backgrounds which are used to present the overall division situation must be fully legible when viewed under the ambient light requirement for dynamic symbology legibility. Full legibility is defined as the ability of any individual in the audience to easily identify every item

of map data on the displayed background. The backgrounds used for display of the *overall* tactical situation must be identical in area of coverage and level of detail to the backgrounds used on the console for the same purpose. This is the primary background type required for the group display.

(d) In addition to the *overall* tactical situation display background requirement, the ability to display a map background with a degree of detail equal to the standard military 1:50,000 topographic map and with an area of coverage no less than 50 kilometers by 50 kilometers is desirable. The legibility of map detail on this background should be no less than that of the standard military topographic map. The availability of this background not only permits viewing of greater map detail but also allows the user to better associate the map display to the standard military topographic map with which he is familiar. The viewer may have to move closer to the background to identify all detail.

(e) It is also desirable to display backgrounds which are identical to the blowups on the console. These backgrounds can be used when one or more individuals in the audience desire more map detail. The interested individuals may have to move closer to the screen to identify all detail.

(f) If on-line discrete background maps are used, a means for their initial registration will be required. Once registered, they should not require re-registration.

(4) Map overlay input device.

(a) The map overlay input device can serve two purposes in a TOC:

1 The input to the system of freehand graphic data such as that found on an operation overlay (e.g., symbols for boundaries, objectives, phase lines).

2 The input to the system of actual map data (e.g., outlining a hill mass) to allow the user to highlight or modify displayed map backgrounds.

(b) Either use of the device requires that the overlay or the actual map sheet be placed on the device and the data to be input then traced or input to the system in some manner. The device must be large enough to accommodate the map area of coverage for the majority of division tactical situations (i.e., no less than 50 kilometers by 50 kilometers). The size of a 50-kilometer by 50-kilometer area on a scale of 1:50,000 (the scale of maps most widely used in the division) is 1 meter by 1 meter.

(c) Entry of map data or overlay data requires that the map or overlay be registered. The registration must only require an operator to point at and input the UTM coordinates of any two grid intersections diagonally located in relation to each other. The map must not have to be exactly horizontal, vertical, or centered. The device must be able to accept for registration maps which use the UTM grid system. Map areas to be registered may include the junction of two or more map sheets and the junction of two or more 100,000-meter grid zones. The device should accept maps of any scale but must, as a minimum, accept maps with a scale of 1:25,000, 1:50,000, 1:100,000, and 1:250,000.

(5) Map overlay output device.

(a) The map overlay output device requires a copy size sufficient to provide the same area of map coverage as that required for the interactive graphic display console. The map overlay output device copy size must be at least 1 meter by 1 meter. This allows the complete output of most division tactical situation displays for the most commonly used scale and required area of coverage. A 50-kilometer by 50-kilometer area of coverage on a 1:50,000 scale standard military map measures 1 meter by 1 meter.

(b) Division tactical overlays will normally be used with standard scale military maps and therefore must have a 1 to 1 ratio with these maps. However, the device should have the ability to provide copy to any scale desired. As a minimum, the operator must be able to specify scales of 1:25,000, 1:50,000, 1:100,000, and 1:250,000.

e. Timeliness and ease of use.

(1) General.

(a) User acceptance of an automated display system will be greatly influenced by how easy it is to interact with. This is directly affected by how easy the operating procedures are to learn and use as well as how quickly the system responds to each step of a procedure. Ideally, the procedures should be so easy to learn and use that a commander or staff officer could operate the system after watching someone else for a very short period. This, along with a greatly increased ability over manual methods for performing information display functions in the conduct of tactical operations, will assure user acceptance.

(b) Subparagraph e addresses automated display system requirements for timeliness and ease of use. The detailed operating procedures are presented as a guide rather than as firm requirements. The procedures serve two purposes:

I To outline the *interactive capabilities* that automated display systems must have to effectively assist the user in meeting his information display requirements.

2 To illustrate the degree of simplicity that each procedure should have. The two primary factors which must be considered in the design of operating procedures are the ease with which the procedures can be learned and the ease with which they can be used.

(c) It will be noted that the procedures use function pushbuttons. User comments during the experiment indicated that pushbuttons were preferred over "menu selection" by light pen or typed alphanumeric commands. Preference for pushbuttons was influenced by the ease with which pushbutton procedures were learned and remembered. This ease resulted from the logical grouping, individual identification, and straightforward use of pushbuttons.

(d) The preference for pushbuttons is not intended to mean that pushbuttons are to be used for every step in each procedure presented. In fact, the total number of pushbuttons required may be excessive if pushbuttons are used exclusively for the implementation of all the procedures presented. Pushbuttons merely provide a convenient means of standardizing the description of the procedures.

(e) A human engineering study is required to determine the best design for incorporating the procedures to be used. The optimum design may involve the use of pushbuttons in conjunction with other techniques. For example, pushbuttons could be used when the steps in a procedure are few or to initiate the key steps of a long procedure. "Menu selection" or some other appropriate technique could be employed (after the step is initiated by a pushbutton) if the use of pushbuttons for subsequent procedure steps would be impractical or inefficient when considered in the context of the overall design.

(f) The pushbuttons used in the description of the procedures can be illuminated and are either on (lit) or off depending on their state before the operator touches them. This gives the operator positive feedback that his interaction has been sensed by the computer. It also provides a ready reference as to which pushbuttons are currently activated. In addition, the computer is able to light or turn off any and all pushbuttons. This feature assists in leading the operator through the key steps of an operating procedure by allowing the computer to indicate (by blinking or color change) the possible pushbutton selections in an operational sequence. Any technique used in lieu of pushbuttons should also lead the operator through the key steps of the operating procedures.

(2) Interactive graphic display console (individual display).

(a) General.

The usefulness of an automated data base is directly influenced by the ease and timeliness with which the user can interact with it. The primary device for user interaction is the console. The system must

lead the operator through each key step of the operating procedures. For example, if function pushbuttons are used, the system could be programmed to light appropriate pushbuttons to show the operator his choice of alternatives at each step in the procedure. In this case, the pushbuttons should be lit in a color selected to identify them as available alternatives and to differentiate them from pushbuttons which are merely activated.

2 The console operator must be able to add, delete, correct, move, and declutter (offset) any tactical situation display data item. Instantaneous, visual feedback of the operator's actions is required for all manipulations. Data manipulation requires a means for positioning newly created or moved items and also a means for indicating which item in the display is to be deleted, corrected, moved, or decluttered.

3 There are two basic methods for positioning a data item. One method is the use of a map background to "eyeball" the desired location. This position is then indicated to the system by pointing. The other method is by keyboard entry of the coordinates. The console must give the operator the option of using either method. The first method is generally used when the exact location is not critical or when the position needs to be determined through map inspection. Coordinate entry is used for data items with specific coordinates. Coordinate entry must not require grid zone designation (entry of grid zone designation should be optional). Additionally it must allow a 4-, 6-, or 8-digit entry depending upon operator preference. The map currently registered and displayed can be used by the system to interpret the coordinates entered by the operator.

4 The preferred method for the selection of items to be deleted, corrected, decluttered, or moved is to point at the item. Ideally, the operator should be able to indicate which item is to be manipulated by touching it with his finger, provided the technology, cost, and complexity of implementation support this method. Other less desirable (but state-of-the-art) methods for pointing are light pens and trackball- or joystick-controlled cursor.

5 The addition, deletion, correction, declutter, or movement of display data items must require a minimum of operator effort and training. There are three basic types of data items. They are alphanumerics, military unit symbols, and graphics. The following procedures for the manipulation of the three types of data items are meant to be a guide rather than an absolute. The intent of each procedure is to provide maximum ease of use.

(b) Data item creation. Data item creation should require a procedure similar to that listed below:

- 1 Press the CREATE data item pushbutton.

2 Select the categories the data item will be a member of by pressing the appropriate category pushbuttons. (See subparagraph (i) below.)

3 Press one of three data type pushbuttons: A/N, MILITARY SYMBOL, or GRAPHIC.

4 Press the desired color pushbutton (e.g., RED for red).

5 Point to the desired location on the screen or type in the coordinate location. (There should be visual feedback whenever a coordinate is typed to allow the operator to determine if the correct coordinate is being typed.)

6 Create the desired item by using the procedure discussed in the following subparagraphs.

a Alphanumerics.

(1) Alphanumerics are most effectively created with the ASCII keyboard. A special key for the coordinate position dot associated with some alphanumerics (e.g., • TANK, • TRUCK) must be provided, since the ASCII period does not stand out and its location is generally not precise. A marker must appear on the screen to indicate to the operator the position of the next character to be added.

(2) The ability to space left, right, up, and down is required to allow the operator to format the data item to suit his needs. He must also be able to backspace in order to make corrections.

b Military unit symbols.

(1) In creating military unit symbols, pushbuttons should be used to select a headquarters, center of mass, or trains symbol. If the symbol is to depict a proposed or task force symbol, the appropriate pushbuttons should be pressed. Branch duty symbol selection is then accomplished by pressing a pushbutton. The following branch duty symbol pushbuttons should be provided:

AIRBORNE	ARMOR	ENGINEER AIR DEFENSE
ARTILLERY	AVIATION	INFANTRY
AIRMOBILE	CAVALRY	MAINTENANCE
ANTITANK	CHEMICAL	PSYCHOLOGICAL OPERATIONS
FIELD ARTILLERY	ENGINEER, BRIDGE	SIGNAL
TRANSPORTATION		

(2) At least 10 additional pushbuttons must be provided for operator created branch duty symbols. (See subparagraph (g) below for creation procedures.) The operator must have the option of superimposing at least two branch symbols (e.g., armor, infantry) in the creation

of a military unit symbol. An easily identifiable point such as the lower left corner of the flag should be established as the location of flag symbols with no staffs. The system should lead the operator through the addition of the left and right identifications and the echelon. A marker must advance automatically to each of these locations. Each location must allow for the entry of up to four ASCII characters.

c Graphics.

(1) The creation of graphic items such as boundaries, frontline traces, trench lines, and freehand symbols by a series of short line segments must be possible by both pointing and coordinate location. The procedure should require only that the operator specify the points of inflection, the end point, and the type graphic (solid line, dashed line, trench symbol) being created. The following line-type graphic symbol pushbuttons should be provided:

SOLID LINE
TRENCH, BASIC SYMBOL
WIRE, CONCERTINA, SINGLE

DASHED LINE
TANK OBSTACLE, TYPE UNSPECIFIED
LINE OF CONTACT (defensive front-line trace)

At least two additional pushbuttons must be provided for operator created line-type graphic symbols. (See subparagraph (g) below for creation procedures.) The system should automatically connect the points with the line type selected. In the case where pointing is used to specify coordinate location, it is desirable to have a rubber band line segment effect which allows the operator to see where the line will be before fixing the inflection point.

(2) The creation of circles or ellipses should be indicated to the system by pressing the CIRCLE or ELLIPSE pushbutton. The operator then indicates the radius or major and minor axes by pointing to their particular locations on the screen. A continuously visible size variation ability at this point is desirable.

(3) The creation of individual graphic symbols such as mines and control points should use pushbuttons for the selection of the desired symbol. The following graphic symbol pushbuttons should be provided:

OBSERVATION POST
COORDINATING POINT
MINE, ANTITANK
MINE, ANTIPERSONNEL
POL POINT, GROUND (combat service support installation)

AMMUNITION SUPPLY POINT, ALL TYPES
(combat service support installations)
AID STATION (combat service support installation)

At least five extra pushbuttons must be provided for operator created individual graphic symbols. (See subparagraph (c) below for creation procedures.) The coordinate location of the symbols will be assumed to be at their center.

7 If the operator desires to start over at any point, he should only have to press the ABORT pushbutton. This returns the console to the operational state it was in before the CREATE pushbutton was pressed.

8 Press the COMPLETE pushbutton. This should leave the previously selected CREATE, category, symbol type, and color pushbuttons lit. The operator can then create several data items of the same type without reselection. He should also have the option of reselecting categories, symbol type, or color at any time before the COMPLETE pushbutton is pressed. The CREATE pushbutton will remain activated until the operator turns it off.

(c) Data item correction. The procedure for correcting symbols in a display should be similar to that listed in the following subparagraphs:

1 Press the CORRECT data item pushbutton.

2 Point out the item to be corrected. (Visual feedback as to which symbol was selected should occur.)

3 Correct the symbol by using the procedure discussed in the following subparagraphs for that type item. If a color change is all the operator desires, he should only have to press the appropriate color pushbutton.

a Alphanumerics. Alphanumeric correction must allow for advancing or backspacing to any character in the data item. A marker must indicate which character will be changed if an ASCII key is pressed.

b Military symbols. The procedure for military unit symbol correction must also use a marker to indicate to the operator which portion of the symbol the system is ready to change. The marker under operator control either advances or backspaces through the parts which make up the data item (flag, branch, identifications, echelon). This allows him to change any or all parts of the item.

c Graphics. Line segment graphic item correction is much like the correction of alphanumerics and military unit symbols as a marker indicates to the operator which inflection point the system is ready to change. The graphic type (i.e., solid line, trenches) is also subject to change. Correction of circle radiiuses or ellipse major and minor axes requires indicating the new radius or axis by pointing to its

location on the screen. Correction of individual graphic symbols (i.e., mines, control points) should only require pressing the pushbutton for the desired symbol.

4 If the operator desires to start over again he should only have to press the ABORT pushbutton.

5 Press the COMPLETE pushbutton. The console should return to the operational state which existed prior to pressing CORRECT.

(d) Data item movement. The procedure for moving a data item applies to all data types except line segment graphics and should be similar to the procedure listed below:

1 Press the MOVE data item pushbutton.

2 Point out the item to be moved. (Visual feedback as to which item was selected should occur.)

3 Point to the desired new location on the screen or type in the coordinate location. (There should be visual feedback of the coordinate being typed.)

4 If the operator desires to start over at any point he should only have to press the ABORT pushbutton.

5 Press the COMPLETE pushbutton. The console should return to the operational state which existed prior to pressing MOVE.

(e) Data item declutter (offset). The procedure for decluttering a data item applies to all data types except graphics and should be similar to the procedure listed below:

1 Press the DECLUTTER data item pushbutton.

2 Point out the item to be decluttered. (Visual feedback as to which item was selected should occur.)

3 Move the item to the desired new location. The item must appear to move with the pointer. This helps the operator to position it in the least cluttered area of the screen. A line will appear between the item's offset location and its true location.

4 If the operator decides not to declutter the item after all, he should only have to press the ABORT pushbutton.

5 Press the COMPLETE pushbutton. The DECLUTTER pushbutton should remain activated until the operator turns it off.

(f) Data item delete. The procedure for deleting a data item applies to all data types and should be similar to that listed below:

- 1 Press the DELETE data item pushbutton.
- 2 Point out the item or items to be deleted. More than one item can be deleted at a time. As each item is pointed to, it must disappear from the display.
- 3 If the operator decides not to delete the items selected, he should have the option of pressing the ABORT pushbutton, thereby restoring all the temporarily deleted symbols.
- 4 Press the COMPLETE pushbutton. The console should return to the operational state which existed prior to pressing DELETE.

(g) User created symbols. The user must have the ability to create unique branch duty and graphic symbols to be used exactly like the permanent branch duty and graphic symbols.

1 Military unit branch duty symbols. The console must allow the user to create at least 10 branch duty symbols. Each created symbol must be associated with a particular pushbutton on the console. The pushbuttons are used in exactly the same manner as the permanent branch duty symbol pushbuttons in the creation and correction of military unit symbols. The procedure for creating additional branch duty symbols is listed below:

- a Press the CREATE SYMBOL pushbutton. This should cause an enlarged military unit flag (rectangle) to appear on the console screen.
- b Using the create graphic vector procedure, create the desired branch symbol as a series of short line segments inside the flag.
- c Press the pushbutton the branch symbol is to be associated with. The pushbutton should allow the operator to affix a copy of the symbol to it. If a symbol has been previously assigned to this pushbutton, this step replaces it with the newly created branch duty symbol.

2 Graphic symbols.

- a The console must allow the user to create at least five individual graphic symbols. As is the case for branch duty symbols, each created graphic symbol must be associated with a particular pushbutton on the console. The pushbuttons are used in exactly the same manner as the permanent individual graphic symbol pushbuttons in the creation and

correction of graphic symbols. The procedure for the creation of additional graphic symbols is the same as the procedure for military unit branch symbol creation. When the operator presses the CREATE SYMBOL pushbutton, the enlarged rectangular format used in the creation of military unit branch duty symbols provides the operator with a ready frame of reference. Since the operator knows that the enlarged format reduces to the size of a military unit symbol rectangle on a display, he can create the desired graphic symbol to the appropriate size inside the format.

b The console must also allow for the creation of at least two line-type graphic symbols. The created symbol must be associated with a particular pushbutton on the console. The pushbuttons are used in exactly the same manner as the permanent line-type graphic symbol buttons. The procedure for the creation of line-type graphic symbols is the same as that used for the creation of military unit symbols and individual graphic symbols. By using the enlarged rectangular format as the frame of reference, the operator can create a repeatable element of the graphic line-type symbol of the appropriate size inside the format.

(h) Backgrounds.

1 Ideally, background map display should require the operator to only specify the level of detail and the area of coverage desired. Registration with the dynamic symbology should be automatic. If a particular background is to be frequently displayed, the operator must have the option of giving it an identification label which will allow its recall without the operator having to respecify the level of detail and area of coverage. The currently selected categories of dynamic symbology in a newly selected area of coverage must appear automatically.

2 The procedure for obtaining a desired map background should be similar to that listed below:

a Press the SELECT MAP pushbutton.

b Use ASCII keys to type in the desired map identification label if the map is one that has been identified previously.

c If the desired map has not been identified, select the desired detail by pressing the appropriate pushbuttons (i.e., ROADS, GRIDS, RIVERS, TOWNS). Type in the coordinate (grid zone designation and four or six digits) for the extreme lower left and upper right corners of the desired area of coverage.

d Press the SELECT MAP pushbutton again. This causes the desired map to be "splashed" and the pushbutton to be turned off. (The map must be displayed in 15 seconds or less.)

3 The operator should be able to add or subtract map detail. This should only require that he press the appropriate map detail pushbutton (i.e., ROADS, RIVERS, GRIDS, TOWNS). Detail will either be added or subtracted depending on whether or not it is currently displayed.

4 If at any time the operator wants to give a label identification to the map currently displayed so that it can be recalled, he should be able to do so by pressing the ADD MAP ID pushbutton and then typing the desired label on the ASCII keyboard. Map identification labels should be console peculiar (i.e., each console will have its own set of labels). Other console operators will be able to retrieve a map identified on a different console by using the appropriate prefix for that console.

5 The label of the map currently displayed should appear at a particular location on the display screen. If that particular combination of detail and area of coverage has not been labeled, no label should appear. A list of labels currently being used to identify maps on that console should be available upon request of the operator. Maps may be deleted from this list by pressing the DELETE MAP ID pushbutton and pointing to the label of the map to be deleted.

6 If the ideal background map display procedure described above is not possible, discrete background maps, although not as flexible, offer an alternate approach. If the user is given an infinite number of on-line discrete background maps, he can approach the flexibility of the ideal map described above. However, an infinite number of on-line maps that have varying areas of coverage and different combinations of detail is not realistic. Realizing this, the following considerations are provided to assist in the specification of systems that use discrete map background presentation.

a Each display system must have a number of discrete maps on line. Each map in the set must be available within 15 seconds. Initial registration and cataloging of a map must only require that the operator point out two diagonally located grid intersections or two known (diagonally located) points and type in their coordinates (grid zone designator and 4, 6, or 8 digits). The group display will require a method for indicating these two coordinate locations to the system. The operator must assign an identification label to the map so that it can be easily recalled. This label must be visible whenever the map is displayed. Once the map is registered, it must not require registration upon recall.

b Background orientation or scale must be immaterial when registering a map. There must be no requirement that the map be exactly vertical or centered or that it have a particular magnification factor. In addition, a means for easily changing on-line backgrounds either singly or as a set must be provided.

(1) Data category selection.

1 The use of transparent overlays or "drops" is commonplace in a TOC. Each drop depicts a specific data category or categories such as friendly unit locations and boundaries and is placed over a hard copy map. The drops can be viewed singly or in combination, one drop on top of the other. The use of drops points out the user requirement for the selective viewing of data.

2 An automated display system must be able to store and display data items by category. The use of categories is analogous to the use of manual drops. The easy assignment of a data item to a category or categories, along with rapid access to and display of data items in the desired category or categories, is essential to effective user management and analysis of data.

3 The system should provide for approximately 30 data category pushbuttons on the interactive graphic display console. If the display system is interfaced with other systems such as TOS, some of these pushbuttons will be associated with standard categories to permit the efficient transmission and receipt of data in the standard categories.

4 When a new data item is added to the system's data base, the system must allow the user to specify which category or categories the data item is to be stored and displayed under. It must be possible to assign a data item to more than one category and to change the category or categories of any displayed data item.

5 Data items associated with a particular echelon (e.g., hostile and friendly units) may be required to be displayed by echelon for a selected category. For example, a user may wish to display the category containing friendly unit locations but want to see only those units of brigade size or larger. A set of pushbuttons to specify the desired echelons should be provided for this purpose.

6 It is desirable to allow the user the option of specifying the time frame for categories which he selects. An example of the use of this option is the display of reported vehicular movement from (date time group) to (date time group). If the option is not exercised, the system displays all data for the selected category and echelon. The time frame applies to all categories selected for display.

7 The procedures listed below are provided as a guide to data category selection and category change. Initial assignment of a data item to a category is discussed in the procedure for data item creation (subparagraph (b) above) and the section on TOS message receipt (subparagraph (k) below).

a Selection of data categories for display. (It is assumed that the user has already selected and has displayed the map background area of coverage.)

(1) Press the desired echelon pushbuttons for the categories to be displayed. The echelon selection applies to all displayed categories which have echelon associated data items.

(2) Press the desired category pushbuttons. This causes the display of data items in the desired categories for the specified echelon(s). Pressing a category pushbutton which is lit disengages the pushbutton, turns the light off, and causes all data items belonging to that category to be removed from the display.

b Changing the category of a displayed data item.

(1) Press the CHANGE CATEGORY pushbutton. This causes all category pushbuttons which are lit to be turned off.

(2) Press the desired category pushbuttons.

(3) Point to the data item (or data items, if more than one data item is to be stored in the new categories) on the display. (Visual feedback to indicate the selected symbols should occur.)

(4) Press the CHANGE CATEGORY pushbutton. This assigns the selected data items to the new categories. The light on this pushbutton turns off, and the previously lit category pushbuttons turn on.

(5) The user may press the ABORT pushbutton at any time during the procedure. This returns the display to the state it was in before the procedure was initiated.

(j) History storage.

I A means for storing display scenes is required. Stored scenes can be used for briefings on the large screen, unit historical data, and the development of different plans and analysis. The user must have the ability to manipulate the data items in any recalled scene. The system must also have the capability to re-store these modified display scenes. The procedure for storing display scenes should be similar to that listed below:

a Press the STORE HISTORY pushbutton.

b Type a brief description of the scene that was stored. Visual feedback of what is typed should appear on the lower edge of the scene.

c The system adds this scene description to its current listing of stored scenes for that particular console.

d Press the STORE HISTORY pushbutton again. This completes the storage procedure and the pushbutton light goes off.

2 The procedure for the recall of stored display scenes should be similar to that listed below:

a Press the RECALL HISTORY pushbutton. A list of the currently stored scene descriptions for that console is displayed. (If the console operator wants a listing of another console's stored scenes, he types that console's prefix.)

b Point to the scene description desired. The selected scene must appear within 15 seconds. Deletion of scenes in the list should only require pressing the DELETE pushbutton and pointing to the appropriate description.

c Return to the display shown prior to history recall is accomplished by repushing the on-off RECALL HISTORY pushbutton.

(k) Data item transfer to and from TOS.

1 Each console must have the ability to send data items to, and receive data items from, TOS. Update of the TOS data base should only require that the operator press the TOS DATA pushbutton and point to the data item(s) to be sent. The data items, along with their associated free text, are sent to TOS when the TOS SEND pushbutton is pressed.

2 TOS data is either received as a result of a standing request for information (SRI) or a query from a particular console. The SRI or query establishes the console data category or categories that incoming data items are assigned to. When a data item is received, it is automatically displayed and highlighted if it is in the area of map coverage displayed. It is displayed and highlighted regardless of the currently selected categories. The item continues to be highlighted until the operator points to it and presses an ACCEPT, SAVE, or REJECT pushbutton to indicate that he sees the item. The ACCEPT pushbutton adds the data item to the designated display categories. The SAVE pushbutton adds the item to a special TOS save category. Data items in the TOS save category can be transferred to display categories at any time. The REJECT pushbutton deletes the item. Blinking is an acceptable means for automatic highlighting although any other means that is equally as attention getting is acceptable. If a data item received from TOS is not in the currently displayed area of map coverage, it appears and is highlighted the first time the operator selects an area of coverage that includes the item's location. Military unit symbols that have branch duty symbols that are not contained in the permanent symbol generator must appear with the first four letters of the branch duty inside the rectangle.

3 When a TOS data item is an update to data already in the system, pressing the ACCEPT pushbutton causes automatic replacement of the previous information. An example is the automatic update of a particular unit's location or the relocation of a particular boundary.

(l) Display transfer between consoles. The transfer of entire displays from one console to another must be provided for. This can be between consoles within an automated display system or between a console in one system and a console located in another system at another echelon. The transfer will generally be in answer to a verbal request for specific information. The procedure should only require that the operator obtain the desired display in the normal manner, press a SEND DISPLAY pushbutton, and type an identification for the console which is to receive the display.

(m) Alphanumeric data associated with a displayed data item.

1 Data items in tactical situation displays have associated data which normally is not displayed with the symbol that represents the item. This data is alphanumeric in nature. Examples of this type of data include the UTM grid coordinate(s) of the data item and free text remarks which elaborate on the data item.

2 Frequently, the viewer of a tactical situation display wants more specific information on a displayed data item. He may also wish to provide his own comments to further clarify the display of the item. A procedure currently used in TOC's is to code significant data items with a number or letter. The numbers or letters are listed with the appropriate clarifying data on the side of the display.

3 An automated display system must have the ability to provide additional data on any display data item upon user request. It must also provide the user with the ability to add his own free text remarks.

4 To obtain additional data on a displayed data item or to add a comment on the item, a procedure similar to that listed below should be used:

a Press the EXTRA DATA pushbutton on the console.

b Point to the desired data item. This causes the display of a three-part format. The display of this format must not replace the graphic display. The format can be displayed on the same screen with the graphic display or on a separate, but nearby, alphanumeric display screen.

(1) The first part of the format is automatically completed by the system and includes, as a minimum, the grid coordinate(s) of the data item. Other data which can be included in this part of the format are the date time group, the originator, and the reliability of the data.

(2) The second part of the format is provided for the entry of optional free text remarks by the originator of the data item. If the data item is transmitted from an outside source such as TOS, the sender's remarks (if any) are entered here. If the data item is originated by the display system user, his remarks (if any) are entered here.

(3) The third part of the format is provided for optional free text remarks by the recipient of the data item. A data item transmitted from an outside source has this part of the format for the display system user's comments (if any).

c Type free text comments (if any) in the second part (originator) or third part (recipient) of the format.

d Press the EXTRA DATA pushbutton. This turns the pushbutton light off and deletes the extra data format from the display.

(n) Miscellaneous controls. A number of control switches or knobs are required on the interactive graphic display console. Many of the controls directly affect the viewability of the display and have been alluded to in previous sections. The controls must be on the console. The console operator should not have to leave his position in order to reach them.

I The controls listed below must be included on the console:

a Dynamic symbology brightness control knob. Turning the knob one way or the other increases or decreases the *overall* brightness of displayed dynamic symbology within the range from maximum brightness to the dynamic symbology being completely faded from the screen.

b Map background brightness control knob. Turning the knob one way or the other increases or decreases the *overall* brightness of the displayed map background. The brightness is controllable from maximum brightness to the map background being completely faded from the screen.

c Restart-reset pushbutton. This pushbutton is used when operator or system error causes the processor to halt. Pressing the pushbutton causes a reload of the display program if necessary and/or resetting of the program parameters to what they were before the halt. The system must be operational within 15 seconds after this pushbutton is pressed. However, return to full operational status within 2 or 3 seconds is highly desirable.

2 The controls listed below should be included on the console:

a Color brightness control knob(s). One knob is provided for each color of dynamic symbology. The knob has the same function and range as the dynamic symbology brightness control knob except that it controls the brightness of an individual color.

b Map feature brightness control knob(s). These controls are necessary if the ideal map background display is practical. One knob is required for each color used to identify a specific map feature (e.g., roads, vegetation, rivers). The function and range of the knob is the same as the map background brightness control knob except that it controls the brightness of an individual map feature color.

c Symbol size control knob. Turning the knob one way or the other varies (within a specified range) the size of all data items except line-type graphic items, circles, and ellipses. When the control is used, all parts of the data items (e.g., the rectangle, the branch duty symbol, the left identification, the right identification, and the echelon) are either enlarged or reduced proportionally. Changing the size of the symbols must not change their apparent map locations.

3 Other controls may be required, depending upon the display technique used. For example, individual dynamic symbology and map background focus knobs may be necessary.

(o) Error notification.

1 The display system must notify the interactive graphic display console operator when he performs a step in a procedure incorrectly. The notification means must be positively attention getting, must be rapid, and must specify exactly what was done wrong. An audio alert such as a bell or buzzer should sound whenever an error occurs. Incorrect attempts to recover from the error cause additional audio alerts. An audio alert is preferable to a visual alert because it precludes the possibility of the operator not detecting the error if he is looking away from where the visual alert is located. Coincident with the audio alert, an error message should be displayed at some standard location. The error message display must not delete the current situation display. The error message continues to be displayed until the operator performs the correct step in the procedure or until he presses the ABORT push-button at which time the error message is deleted and the display returns to the state it was in before the series of commands was initiated.

2 The error message must tell the operator exactly what he did wrong. The use of error codes which require the operator to look up the code to determine the error is not user oriented and is not acceptable. Ideally, the error message should state what step of the procedure

was performed incorrectly. For example, using the procedure outlined for the creation of military symbols, an error message might read: "Last pushbutton depressed was not branch duty."

(3) Group display output device.

(a) The group display device is operated from an interactive graphic display console. Before a display can be shown on the device it must be displayed on the console. It is then transferred to the group display by pressing the GROUP DISPLAY pushbutton on the console. This action causes both the map background and the selected dynamic symbology to be displayed on the large screen. Once the transfer is initiated, the display must appear on the large screen within 15 seconds. The capability to have the display appear within 5 seconds is highly desirable. Fifteen seconds is the maximum time that a user can be expected to wait without inconvenience for a display to appear on the device.

(b) A number of control switches or knobs are required on the group display output device. These controls are required to improve the viewability of the displayed situation. The controls must be located near the face of the screen, for easy access to a briefer or individual performing viewability adjustments to suit the user. The controls which should be provided with the group display output device are shown below. Each control has the same function (and range) as that described for the interactive graphic display console. Other controls may be required depending upon the display technique.

- 1 Symbol size control knob.
- 2 Dynamic symbology brightness control knob.
- 3 Map background brightness control knob.
- 4 Color brightness control knob(s).
- 5 Map feature brightness control knob(s).

(4) Map overlay input device.

(c) The map overlay input device will be used to input two types of freehand graphic data: overlay data and map features. All data items are input as a series of points. These points will be automatically connected by line segments. Use of the device requires an interactive graphic display console for monitoring the input. The procedure should be similar to that listed below:

- 1 On the console, select the desired area of coverage for monitoring the input. (This should not have to be the exact area registered on the input device.)

2 Press the OVERLAY DEVICE pushbutton on the console. This activates the map overlay input device.

3 Press the desired graphic data line-type, the desired data category, and the desired color pushbuttons on the console. All points input from the overlay device are displayed and connected by the selected graphic line-type in the selected color. The line-type, the data category, and the color can be changed at any time by pressing the appropriate line-type, category, and color pushbuttons.

4 If the map on the input device is not registered, type in the grid coordinates of two diagonally located grid intersections and point to these points on the map. This step should not have to be performed again unless the map is moved or a new map is positioned on the device.

5 For each data item to be input, press the CREATE ITEM pushbutton on the input device.

6 Input the desired data item by pointing to the series of points defining the data item on the overlay. As each succeeding point is selected, the resulting cumulative line segment should appear on the console. If the operator is not satisfied with the last few line segments, he should be able to delete them by pressing the BACKTRACK pushbutton. If the operator is not satisfied with the entire item, he should have the option of starting again by pressing the CREATE ITEM pushbutton again.

7 Press the COMPLETE pushbutton.

8 Input additional items by repeating 5, 6, and 7 above.

9 After all entries have been made, the device is turned off by deactivating the OVERLAY DEVICE pushbutton on the console.

(b) The procedure outlined above can also be used for the input of freehand graphic data directly from a map. As far as the device is concerned, it is immaterial whether the data input is from an overlay or directly from the map as long as the user specifies the category under which each data item is to be displayed. Thus, the device can be used to add additional detail to a displayed map background; for example, outlining of a hill mass or showing an intermittent stream which, because of recent wet weather, has become a significant obstacle to movement by foot and vehicle.

(c) The map overlay input device can also be used for measuring distances on a map. Distance measurement is commonplace in TOC planning and operations (e.g., road movement planning). This device is a "natural"

for distance measurement, since very little effort is required to provide this capability. The measured distances must be within 5 percent of the actual distance. The procedure should be similar to that listed below:

- 1 Press the OVERLAY DEVICE pushbutton on the console.
- 2 If the map on the input device is not registered, type in the coordinates of two diagonally located grid intersections and point to these points.
- 3 Press the DISTANCE MEASUREMENT pushbutton.
- 4 Measure the desired cumulative distance on the map by pointing to the start point, succeeding points of inflection, and the end point.
- 5 Press the COMPLETE pushbutton. This causes the distance measured to appear in meters on the console screen.
- 6 Measure additional distances by repeating 4 and 5 above.
- 7 Turn off the device by deactivating the OVERLAY DEVICE pushbutton. The map overlay input device provides an effective means of inputting and displaying map features of particular interest to a user. The device in effect permits the input of map features which, when displayed singly or in combination, allows the user to tailor the map background to the situation. This means of inputting map features to the system has the potential for meeting the requirements for random selection of map background area of coverage and level of terrain detail. Thus, it approaches the ideal solution to the map background problem.

(5) Map overlay output device.

- (a) The procedure for producing hard copy on this device is similar to that used for outputting a scene to the group display device. The scene must first be displayed on an interactive graphic display console. The PRODUCE OVERLAY pushbutton on the console is then pressed. After typing the desired number of copies, the console should be free to return to other display functions. The time to produce one copy must not exceed 5 minutes. However, a time of 1 to 2 minutes per copy is extremely desirable.
- (b) The map overlay output device should be capable of remote operation. This allows the transmission of overlays to lower echelons which may not have an automated display system. This device may require a small memory unit or buffer to preclude tying up communication lines.
- (c) The overlay reproducer can be used to aid CONOPS. Periodic outputs of important displays could be used whenever the system is not fully operational because of system failures or TOC displacement.

(6) Printer.

(a) The line printer produces alphanumeric hard copy. The alphanumeric data is either received from outside the system (e.g., a transmission from TOS) or output from the system's data base. The hard copy is used for historical purposes (log), for more detailed analysis within the TOC, for dissemination to units or sections having no access to an automated display system, or as an alternative to displaying the alphanumeric data. It can also be used to aid in CONOPS by providing a record copy. Examples of hard copy which could be output by the printer include:

OPORD	INTSUM	SITREP
TASK ORGANIZATION	CHALLENGE/PASSWORD	WEATHER DATA
TABULAR (CHART) DATA	FREE TEXT MESSAGES	FORMATTED MESSAGES

(b) None of the above require hard copy size larger than the 8-inch by 10 1/2-inch size used in the manual system. The printer should provide hard copy in the size normally used in the manual system. This will allow the hard copy to be reproduced on available reproducing equipment (e.g., xerox, thermofax).

(c) The print area must be visible to the user. This precludes the possibility of output not being noticed by the user or his having to advance the page to read newly received data.

(d) Print speed should be such that a full page of output with single-spaced lines can be obtained within 30 seconds. Thirty seconds is well within the capability of available medium-speed printers.

(e) Receipt of data from an outside ADP source must be automatic. When the printer is activated, an audible alert (adjustable by the operator down to zero volume) must indicate to the operator that output is being printed.

(f) Output of alphanumeric data from the system's data base should only require the display of the desired categories and pressing of the PRINTER pushbutton. The pushbutton should remain lit until the output is produced; then it should automatically turn off.

(g) The procedure for initiating printer copy from the interactive graphic display console is not intended to restrict initiation of printer copy to the interactive graphic display console alone. Certain types of alphanumeric data may be better displayed on the alphanumeric display console and then output to the printer by means of a pushbutton on the alphanumeric display console.

(h) Transmission of alphanumeric data from one display system to another display system's printer should be possible through the interactive graphic display console. The procedure should only involve displaying the appropriate categories, pressing a SEND ALPHANUMERIC pushbutton, and typing the prefix of the printer where output is desired.

(7) Alphanumeric display console.

(a) The alphanumeric display console is the primary device used for the input, display, manipulation, and transmission of alphanumeric data. Some of the functions the device should be able to perform are listed below:

1 Display of message formats which are used for data input into the system, data input to TOS, and query of the TOS data base.

2 Display of alphanumeric data, to include tabular data, contained in the system's data base.

3 Manipulation and update of displayed alphanumeric data.

4 Composition and display of free text data.

5 Transmission of formatted data to TOS.

6 Transmission of formatted and free text data to another display system's alphanumeric display console, interactive graphic display console, or line printer.

7 Transmission of displayed alphanumeric data to an interactive graphic display console of the display system.

8 Output of displayed alphanumeric data on the system's line printer.

(b) The procedures implemented to accomplish the functions listed above must provide for maximum ease of use. The procedures recommended for the interactive graphic display console should be referred to for the degree of simplicity and user convenience that is desired.

(c) Certain design features should be incorporated to facilitate operator use of the device. Examples of these design features are listed below:

1 Instantaneous visual feedback when a character is being typed or a manipulation is being performed so the operator can immediately see the result of his action.

2 A brightness control with which the operator can adjust the display brightness to the ambient light environment.

3 A standard (typewriter) keyboard layout for convenient entry of ASCII characters.

4 A control to shift left, right, up, or down.

5 Margin and tab controls to assist in formatting data as well as completing blank formats.

6 A marker symbol to assist in positioning data by indicating where the next character will appear.

f. Reliability, availability, and maintainability.

(1) General.

(a) An automated display system is required to operate in a field environment, under all weather conditions. It must perform the display functions associated with mission accomplishment for command and staff personnel in a tactical operations center. Key components of the system are required to operate continuously (24 hours per day, 7 days per week) for varying periods. The system moves whenever the tactical situation dictates that the TOC must displace.

(b) The display functions of an automated display system involve the input, processing, manipulation, storage, retrieval, display, or output of data contained in TOC working files such as the current friendly and enemy situation files. The inability to perform one or more of the above functions even for short periods (e.g., 10 to 20 minutes) degrades system performance, can affect mission accomplishment, and is undesirable. Therefore, to perform satisfactorily in a TOC, the system must meet high standards of reliability, availability, and maintainability. The equipment must be rugged, compact, lightweight, and must not degrade mobility of the TOC. The operational availability of the system should approach 100 percent. This should take into account both hardware and software caused failures.

(c) The following subparagraphs discuss from a user viewpoint the reliability, availability, and maintainability requirements for components of an automated display system. The requirements are based on observations made during the experimentation and provide a point of departure for refinement.

(2) Display processor.

(a) The display processor controls the operation of an automated display system. The system components which it controls become inoperable whenever the processor fails. Consequently, the processor's reliability, availability, and maintainability requirements are the most stringent. Unlike any other component of the system, the processor is required to operate on a 24-hour-per-day basis for long periods.

(b) Preventative maintenance actions are normally scheduled during periods of expected decreased activity in the TOC. However, if it is necessary to return to full operation when preventative maintenance is being performed, it must be possible to complete or terminate the preventative maintenance so that full operation is restored within 15 minutes. The processor must be designed in such a manner that any unscheduled maintenance action takes no longer than 15 minutes. This time is from the moment it is first sensed that the system is down until the system is again operational. The time includes fault detection, isolation, and correction as well as administrative and supply delays. Any time longer than 15 minutes could severely hamper continuity of operations and could force the user to revert to some other method of operation to replace functions performed by the system.

(c) The time to perform unscheduled maintenance must not only be a minimum, but the number of unscheduled maintenance actions occurring in a given period must be as few as possible.

(3) Interactive graphic display console. The console is the primary device used to interact with the computer and its data base. If there are several consoles located within a TOC, the failure of one console, although detrimental to the console user, would not result in total system failure. For this reason, the reliability and maintainability requirements for the console are not as critical as those for the display processor. However, the reliability and maintainability of the consoles should be such that principal users (i.e., G2, G3) of the system are not deprived access to a console for more than 15 minutes.

(4) Group display output device. The group display is used primarily for briefings and group viewing. Since it is not interactive and is only used as an output device, its reliability and maintainability requirements are not nearly as critical as those of the display processor or consoles. However, to be useful and considered an asset by the user, its reliability and maintainability must be high. Failures while briefing the commander should happen infrequently. Downtimes longer than 5 minutes have no real limit, although they should be reasonable (i.e., not more than several hours). This downtime requirement stems from the reality that the commander, after waiting 5 minutes, will most likely continue the briefing from a console rather than wait for the group display to return to operation. When the group display is not

actually being used for a briefing but is being used to display a situation of interest to a number of people in the TOC (e.g., the current enemy and friendly situation), the temporary failure of the group display can be tolerated because the situation shown on the group display can be seen on a console.

(5) Map overlay input device. Use of the map overlay input device is not expected to be continuous; but when the device is required, its availability and reliability must be high. Maintainability of the device should be such that any unscheduled maintenance action does not exceed 30 minutes. This is the maximum time that a user can reasonably be expected to wait if he has map or overlay data which he needs to input to the system.

(6) Map overlay output device. Like the map overlay input device, this device will not be in continuous use. However, it must have high operational availability and reliability. Maintainability requirements are the same as those for the map overlay input device; that is, any unscheduled maintenance action should not exceed 30 minutes.

(7) Printer. The printer is normally on continuously, even though it provides output at unspecified intervals. The two primary uses of the printer are the "logging" of messages from ADP sources outside the automated display system and the output of alphanumeric data contained in the system's data base. Therefore, the operational availability and the reliability of the printer must be high. Maintainability should be such that any unscheduled maintenance action does not exceed 30 minutes.

(8) Alphanumeric display console. If there are several alphanumeric display consoles located within a TOC, the failure of one console, although detrimental to the console user, would not result in total system failure. The reliability and maintainability of the console should be such that the principal users (i.e., G2, G3) of the system are not deprived access to a console for more than 15 minutes.

2-5. TOS Materiel Need Group Display Device (GDD) and Analysis Console (AC) Characteristics.

a. General.

(1) This paragraph provides comments on the stated characteristics for automated displays as listed in the DA approved MN for TOS document dated November 1972: "DA Approved Materiel Need for the Tactical Operations System (U); (MN for TOS (U)); Basic Document United States Army Combat Developments Command Intelligence and Control Systems Group; ACN: 15675; dated November 1972."

(2) The TOS MN specifies two components that will be used to display data: the group display device (GDD) and the analysis console (AC). The characteristics and associated rationale for these two components are reprinted here directly from section VI of the MN for TOS as an aid to the reader. Each characteristic and its associated rationale is followed by a comment. The comments are provided in the light of FM116 experience and the experimentation findings relating to automated display systems in general. To obtain the full significance of the comments, it is essential that the reader read paragraphs 2-3 and 2-4 of this section.

b. Group display device.

(1) Quote and comment.

(a) Quote.

"(5) Group Display Device. The GDD is the automated output of TOS that portrays friendly and enemy units, locations, boundaries, zones, or areas on a tactical map background. The device is used in the same manner as is the current operations and planning displays: for the conduct of current operations, to assist in coordination, as a means of conveying plans and orders, and to facilitate planned and future operations. The GDD must be capable of displaying automated symbology driven from the computer or inserted by the operator. Provisions must be made for refreshing the data when received; the device must also be capable of portraying the situation on operator demand--showing units, locations, or maneuver traces applicable in the queried time period. The operator must also be capable of portraying or excluding any type of detail he selects, e.g., portray only armor units, infantry units of company size or larger, artillery units within a specified range of a selected ground point, etc. To provide for continuity of operation in the event of failure of the display or its associated equipment, provisions should be included to provide hardcopy output of the last situation presented prior to failure. Optimally, the hardcopy output should be such as to permit manually updating on the face thereof. The group display device shall have the following characteristics:"

(b) Comment. The GDD is used primarily for briefings and group viewing. Therefore, there is no requirement for direct interaction with the display. Scenes shown on the display are created in advance on an interactive graphic display console and transferred to the GDD when required.

Scenes transferred to the GDD can be recalled from storage (e.g., tape, disk) or can be transferred from a current console display. Control of the GDD is accomplished through an interactive graphic display console. The overlay reproducer requirement should not be associated with the GDD requirement. The overlay reproducer should be a separate item of equipment, and its requirements should be stated separately.

(2) Quote and Comment.

(a) Quote.

"(a) Display Unit. The group display unit shall have:

1. Capability to display alphanumeric, symbolic, and graphic information from a digital data source onto standard (1:50,000; 1:100,000; 1:250,000; 1:1,000,000 scale) US Army map representation or their projections. The device will also accommodate other maps, mosaics, or photographs (or their representations) and will accept nonstandard, shrunken, or stretched scales. It will be capable of displaying individual sheets or arrays of contiguous maps on which symbols are superimposed by signaling from the supported system's computer.

RATIONALE: Maps, mosaics and photographs provide user with flexibility of backgrounds required to provide complete and rapid analysis of the tactical situation. The map sizes are the most common presently used sizes. Arrays of contiguous maps will reduce map switching when the tactical situation is near the edge of a map sheet."

(b) Comment. The GDD map requirement is identical to the interactive graphic display console map requirement. (See comment c (1)(b) below.) Any display on the console should be transferable to the large screen and should appear as an enlarged copy of the console display.

(3) Quote and comment.

(a) Quote.

"2. Capability of displaying from 200 (minimum) to 300 (maximum) different symbols at operator discretion in near real-time on a 4 x 4 foot (minimum) to a 6 x 6 foot (maximum) area.

RATIONALE: Two hundred symbols is the estimated user will have displayed to describe the tactical situation. Three hundred is the maximum the user can use and still

"read" the screen. FM's 2130 and 2131 contain approximately 250 symbols; the inclusion of an additional 29 topographic symbols leave a margin of 21 for expansion to include emerging sensor symbology. The 4' x 4' size is for readability requirements while the 6' x 6' size reaches the maximum acceptable weight for transport requirements."

(b) Comment. The symbol capacity requirement is identical to the interactive graphic display console symbol capacity requirement. The number 200 to 300 is unrealistic. Most division tactical displays do not contain more than 75 military unit symbols. In addition, not all symbols in FM 21-30 are used frequently enough to justify inclusion in a permanent symbol library. Only the most frequently used symbols should be in the library. The user should be able to add other symbols to this library when required. The size of the GDD display image is dependent upon the expected audience size and screen location (van, tent, etc.). For most division briefings, the audience size is not expected to exceed 20 people. Rules of thumb indicate that each viewer requires 6 square feet of area; that the closest viewer be no closer to the GDD than twice the width of the screen; and the farthest viewer be no farther from the GDD than five times the width of the screen. The larger the screen, the larger the total area required (i.e., total area = viewing area + unused area in front of the screen).

(4) Quote and comment.

(a) Quote.

"3. A surface whereby symbols can be seen from minimum distance of 10 to 15 feet in any lighting environment ranging from total absence of external light to direct sunlight.

RATIONALE: the 15' minimum is the estimated maximum the user can be from the screen and still review the tactical situation. The ten foot limit provides readability of displayed symbols."

(b) Comment. The requirement for viewing in direct sunlight is unrealistic. Even if the GDD is operated outdoors, a means of shielding the display surface is acceptable. Subparagraph (3)(b) above discusses the expected audience size for the group display and the rules of thumb for determining viewing distance. Symbols should be fully legible from the maximum viewing distance.

(5) Quote and comment.

(a) Quote.

"4. Capability of providing a hardcopy (transparent) reproduction via the overlay reproducer.

RATIONALE: Provides for analysis and briefings of the tactical situation away from the location of the GDD. The hardcopier must operate in the same environment as the GDD. Overlays must be able to be used within standard size maps and grease pencils."

(b) Comment. This characteristic should be listed with the overlay reproducer characteristics instead of those for the GDD. (See (28)(a) below.)

(6) Quote and comment.

(a) Quote.

"5. Capability of displaying graphical situation maps based on information from the data base and the Display Control Console. Military symbols and abbreviations should be displayed in accordance with FM 21-30, FM 21-21, and AR 320-50. In addition, the display will provide line segments, chords and conics.

RATIONALE: Provides flexibility and accurate, updated information to the commander in symbols and abbreviations familiar to him."

(b) Comment. The requirement for AR 320-50 is unnecessary. The TOS data element dictionary establishes the legal words to be transmitted to and from TOS. These legal words should be standard for all Army ADP systems. FM 21-21 should read: FM 21-31. The "display of line segments, chords and conics" does not sufficiently describe the requirement for display of symbology. See paragraph 2-6 of this section for the recommended symbols.

(7) Quote and comment.

(a) Quote.

"6. A multicolor projection capability including, at least red, green, near-white and near-black. Blue and Brown are required as soon as the state-of-the-art permits.

RATIONALE: Enables the commander to assimilate and analyze the tactical situation faster and easier. The four colors is the minimum needed for ease of

distinction and analysis. Six is the maximum controllable and distinguishable by the user."

(b) Comment. Red, green, white, black, blue, and brown are the current standard military map colors. Dynamic symbology shown against the standard military map background must not blend with the map. It should be highly contrasting. At least three colors for dynamic symbology are required and up to six colors are desirable. Further investigation is required to determine the best colors.

(8) Quote and comment.

(a) Quote.

"7. Capability of providing visual distinction between friendly and enemy locations, and depicting specified areas and differentiating them from the surrounding terrain.

RATIONALE: The commander must be able to differentiate between friendly and enemy forces."

(b) Comment. Color coding of friendly and enemy symbols is a requirement. Shape in addition to color coding adds little. TOC personnel need to rapidly and unmistakably differentiate enemy symbology from friendly symbology.

(9) Quote and comment.

(a) Quote.

"8. Incorporation of state-of-the-art micro-miniaturized circuitry.

RATIONALE: Provides lightweight, electronic modules that are maneuverable and maintainable in the field."

(b) Comment. Characteristics should not list a particular technology. The state-of-the-art is rapidly changing. The characteristic should be more general and should state that the equipment should take advantage of the latest state-of-the-art developments that aid in making the equipment small, lightweight, rugged, reliable, maintainable, and mobile.

(10) Quote and comment.

(a) Quote.

"9. A data update capability.

RATIONALE: Reduces operator involvement and human errors, and will provide greater system flexibility."

(b) Comment. Data on the GDD is updated by transferring the latest display from a graphic display console.

(11) Quote and comment.

(a) Quote.

"10. Compactness and be comprised of modular components. It must be mountable in standard vehicular mounted shelters normal to the echelon of employment.

RATIONALE: Modularity will facilitate maintenance and repair."

(b) Comment. Concur.

(12) Quote and comment.

(a) Quote.

"11. A regenerative capability, allowing the information on display to persist without having to interrogate the computer.

RATIONALE: Requires integral display memory and reduces operator involvement. Keeps the operator from having to repeatedly query the data base for the same information."

(b) Comment. A regenerative capability (e.g., refresh buffer) may not be required for some techniques. The characteristic should read: "The display on the GDD must persist indefinitely without access to the CPU." If the symbols require refreshing, a dedicated refresh device may be needed.

(13) Quote and comment.

(a) Quote.

"12. Capability of secure remote operation from the computer via a data terminal.

RATIONAL: Provides system security between the GDD and RCC/CCC."

(b) Comment. A display system contains its own processor. The characteristic should read: Capability of secure remote operation from the TOS computer via a data terminal.

(14) Quote and comment.

(a) Quote.

"13. Capability of highlighting a set or combination of symbols which are of special attention or require immediate action.

RATIONALE: Provides easy recognition of critical groupings or symbols."

(b) Comment. Highlighting on a permanent basis is best done by color. However, other techniques such as increasing the brightness of the critical symbols are acceptable. The preferred method for temporary highlighting is to cause the critical symbols to blink.

(15) Quote and comment.

(a) Quote.

"14. Capability of transmitting the display to any other GDU or auxiliary device within the field Army area. Will provide capability to display any input from a connected auxiliary console display.

RATIONALE: Provides digital transmission of graphic information for liaison, coordination and control purposes. Also provides hardcopy reproductions of Auxiliary Console Graphic Displays (Auxiliary Consoles have no graphic hardcopy capability other than this means)."

(b) Comment. This should be a console characteristic instead of GDU characteristic. The graphic hardcopier should operate independently from the GDU.

(16) Quote and comment.

(a) Quote.

"15. Capability of functioning in the field Army electromagnetic environment and must not interfere with other collocated communications-electronic equipments and systems. The system must comply with the electromagnetic compatibility requirements of MIL STD-461A.

RATIONALE: Display device must not effect performance of existing, working electronic systems within the field Army."

(b) Comment. No comment.

(17) Quote and comment.

(a) Quote.

"16. Compatibility with state-of-the-art peripheral and central processing devices of ARTADS and projected communications systems of the time frame.

RATIONALE: Insures easy fielding and interfacing with existing ADP systems and communication networks/systems."

(b) Comment. No comment.

(18) Quote and comment.

(a) Quote.

"17. Man-machine relationship will be in accordance with human engineering factors standards and user operational requirements.

RATIONALE: Requires development of simple, easy interfaces which will reduce the time required for operator intervention."

(b) Comment. The man-machine interface requirement is extremely important and needs to be more specific. See the procedures in subparagraph 2-4e of this section.

(19) Quote and comment.

(a) Quote.

"18. The design will be such that the proposed display, when operated in conjunction with the digital data source, complies with the provisions of AR 530-4 and the NACSEMS 5100 Series.

RATIONALE: The display must comply with existing Army regulations and Federal Standards pertaining to signal security."

(b) Comment. No comment.

(20) Quote and comment.

(a) Quote.

"19. The ability to display a cursor symbol to position circles, vectors, plotting points and symbols on the display surface.

RATIONALE: Allows the operator to find, mark and move (add, delete) items on the display screen with a minimum of searching and confusion."

(b) Comment. This requirement is not necessary for the GDD since the device is not required to be interactive.

(21) Quote and comment.

(a) Quote.

"20. Random selection and display of any one map under the control of either the operator or data source.

RATIONALE: Requires rapid map changing. Can be operator controlled for corrections or magnification of map area or computer controlled to provide a graphical response to a query."

(b) Comment. The map background is a part of any tactical situation display. As such, the desired map background should appear automatically when a display is transferred to the GDD.

(22) Quote and comment.

(a) Quote.

"21. Will have the capability to display approximately one-fourth of the map area for 2X magnification of both horizontal and vertical dimensions. This will be a real or near-real time capability.

RATIONALE: For detailed analysis and control by commanders. The magnification of map results in a greater display of detail, especially needed in static tactical situations. The response times should be very near the query response times given in Annex A."

(b) Comment. The ability to provide map background magnification on the GDD is desirable.

(23) Quote and comment.

(a) Quote.

"22. Distortion of the projected map will be 0.0% to 0.5%.

RATIONALE: Provides an accurate, readable map with easily distinguishable symbols."

(b) Comment. Minor distortion of the map background is only important in its effect on the user's perception of dynamic symbol placement accuracy. The characteristic appears to assume a projection technique as the means of displaying maps. The technique should not be specified.

(24) Quote and comment.

(a) Quote.

"23. Provide for constant relative registration of the computer driven display and the map background through magnification modes.

RATIONALE: Limits and ties the active display distortion to Characteristic C(5)(a)22."

(b) Comment. In display systems evaluated during the test, the enlargement of an area of the map tended to improve the symbol placement accuracy since inaccuracies are constant in relation to screen height and width. Map magnification increases the physical dimension that 1,000 meters occupy, thus the symbol placement accuracy as perceived by the eye is increased.

(25) Quote and comment.

(a) Quote.

"24. Highlight updated information until acknowledged by the operator.

RATIONALE: Permits the commander to be advised graphically of current events and highlight the most recent for required review. After review and acknowledgement, the highlighting can be stopped and the correct symbol and color can be inserted on the display."

(b) Comment. This requirement applies to the console, not the GDD.

(26) Quote and comment.

(a) Quote.

"25. Capability for retaining the existing image if the channel to the computer is interrupted. Also desired is the automatic capability of reproducing on the overlay reproducer all information displayed immediately preceding a GDD or associated equipment failure. While inclusion of this capability may be

presently prohibitive for economic reasons, it is inherent in providing adequate continuity of operations to support mission execution.

RATIONALE: Provides a degraded mode of operation if display device or data link fails. Insures continuity of operations, limits loss of information and limits the size of the manual backup system."

(b) Comment. GDD persistence for the purpose of CONOPS may not be required. The local display processor provides CONOPS if the TOS data link fails. The concept of using the overlay reproducer for CONOPS is good. (See (28)(b) below.)

(27) Quote and comment.

(a) Quote.

"(b) Display Control Console (DCC)****."

(b) Comment. The DCC is unnecessary. Control of the GDD is through an interactive graphic display console.

(28) Quote and comment.

(a) Quote.

"(c) Overlay Reproducer. For the purposes of this document, an overlay reproducer is defined as the device which produces permanent, transparent overlays which are suitable for use with standard Army maps, or their projections. The overlay will be computer generated and shall be capable of printing all symbols displayed on the GDD. The environmental characteristics of the overlay reproducer are identical to those required for the Group Display for both storage and operating conditions. Overlays should be on a single transparent sheet capable of multiple reproductions to coincide with the size of the display, any part thereof or the size of standard Army tactical maps e.g., 22" x 29"; 28" x 36" is required for the 1:1,000,000 map. The overlay reproducer shall have some method to distinguish between friendly and enemy symbols.

RATIONALE: The reproducer produces graphic situation overlays for use away from the device. Its application in a tactical environment will require a hardcopy capability. The overlay can be then used with a

hardcopy Army map or hardcopy projection. Thus, it is required that the overlay relate on a 1:1 ratio with the correct map or map representation size. The data being printed is from the data base of the GDD and controlled registration (1:1) is needed. The reproducer is mounted and operated in the same (or similar) locations as the main TOS components, and must withstand the same environmental conditions. Provides flexibility if the GDD is in the magnification mode. More than one overlay is needed if several smaller unit commanders are to use the same graphic information."

(b) Comment.

1. The overlay reproducer is a separate device and should operate independently from the GDD and the AC. The reproducer should be designed to produce overlays which are suitable for use with standard scale hard copy maps (not projected maps). The reproducer is required to make copies of scenes displayed on the consoles rather than the GDD. (Any scene on the GDD is first displayed on a console, then transferred to the GDD.) A multicopy ability is required. The size of the copy should be at least 1 meter by 1 meter. This is the size required for a 50-kilometer by 50-kilometer area of coverage on a 1:50,000 scale map. The misconception by specification writers that overlays should be the size of standard military map sheets should be avoided. The size requirement must be based upon the tactical area of interest. For a division, this is approximately 50 kilometers by 50 kilometers. The hard copy reproducer should be able to provide copy to any standard military map scale. The copy should be to scale so that it can be overlaid on standard military hard copy maps. Overlays should be on transparent material so that map data can be seen through them. This is not intended to exclude output on other material such as paper.

2. Overlays output in color are desirable. At least two colors are needed to differentiate between enemy and friendly symbology. The colors used should have a high degree of contrast to the paper map colors. The overlay reproducer should be capable of remote operation. This allows the transmission of overlays to lower echelons which may not have an automated display system. Such a device may require a small memory unit or buffer to preclude tying up communication lines. The overlay reproducer can be used for CONOPS. Periodic outputs of important displays could be used during system performance degradation or during TOC displacement. The statement "The overlay reproducer provides flexibility if the GDD is in the magnification mode." Is unclear.

c. Analysis console.

(1) Quote and comment.

(a) Quote.

"(6) Analysis Console (AC). The AC will provide the man/machine interface between the commander's staff and directly supporting units and the computer/data base. The device will operate as a graphical display and an alphanumeric input/output device allowing the user access to the computer's data base. The analysis console will consist of the following modules."

(b) Comment. Interactive graphic display consoles are the man-machine interface between the commander's staff and the computer. As such, their capability for interaction with the computer is extremely important. Procedures for interacting with the computer must be kept simple. (See subparagraph 2-4e of this section.)

(2) Quote and comment.

(a) Quote.

"(a) Map Display Module:

1. Will display Army maps, their representation or their projection in a reduced scale in color on the face of the display.

2. The displayed Army maps will be both standard (1:50,000; 1:100,000; 1:250,000; 1:1,000,000) and non-standard (mosiacs, photographs or their representations).

RATIONALE: To allow the user to view the tactical situation on a standard Army map."

(b) Comment. The display of map backgrounds on the interactive graphic display console display surface is a requirement. Ideally, the operator should be able to specify any area of coverage and desired level of detail (e.g., roads, rivers, towns, grids). The area of coverage should be displayed on the full image area of the screen by only specifying the coordinates of two diagonal corners of the desired area. This ability allows the user to obtain any size magnification that he desires at a given moment. The use of digital map data is one way that this desired background ability could be accomplished. An optical projection technique with zoom and filtering capabilities is another way to attain this background coverage.

(3) Quote and comment.

(a) Quote.

"3. Will provide random selection and display of any one map under the control of either the operator or data source.

RATIONALE: Requires rapid map changing. Can be operator controlled by corrections or magnification of map area or computer controlled to provide a graphical response to a query."

(b) Comment. Random selection of backgrounds is required. The background selection should always be under user control, not data source control.

(4) Quote and comment.

(a) Quote.

"4. Will have the capability of 2X magnification of approximately 1/4 of the displayed area. While in magnification mode, the scale of the display will be approximately equal to the actual map scale. This will be a real or near real-time capability.

RATIONALE: For detailed analysis and control by commanders or staff personnel. The magnification of map results in a greater display of detail, especially needed in static tactical situations. The response times should be very near the query response times given in Annex A."

(b) Comment. The ability to provide map background magnification is required. Magnification should be no problem if the user is able to specify any area of coverage.

(5) Quote and comment.

(a) Quote.

"5. Geometric distortion of the projected map will be 0.0% to 0.5%.

RATIONALE: Provides an accurate, readable map with easily distinguishable symbols."

(b) Comment. Minor distortion of the map background is only important in its effect on the user's perception of dynamic symbol placement accuracy. The characteristic appears to assume a projection technique as the means of displaying maps. The technique should not be specified.

(6) Quote and comment.

(a) Quote.

"(b) Graphic Display Module. Graphic Display Module will:

1. Provide capability of superimposing dynamic alphanumeric and graphic information on the map background.

RATIONALE: Required to provide the flexibility needed and meet system functions for the Analysis Console."

(b) Comment. The ability to display FM 21-30 symbology on a map background is a requirement. For specific requirements see subparagraph 2-4b.

(7) Quote and comment.

(a) Quote.

"2. Provide visual distinction between enemy and friendly forces.

RATIONALE: To allow the commander or staff to differentiate between friendly or enemy forces."

(b) Comment. Color is the best means of visual distinction. At least three colors are required. Three colors allow friendly, enemy, and control measure symbols to be color coded.

(8) Quote and comment.

(a) Quote.

"3. Provide for constant relative registration of the computer driven display and the map background through magnification modes.

RATIONALE: Limits and ties the active display distortion to characteristic c(6)(a)5."

(b) Comment. In display systems evaluated during the test, the enlargement of an area of the map tended to improve the symbol placement accuracy since inaccuracies are constant in relation to screen height and width. Map magnification increases the physical dimension that 1,000 meters occupy, thus the symbol placement accuracy as perceived by the eye is increased.

(9) Quote and comment.

(a) Quote.

"4. Display a cursor symbol (controlled by the operator) to indicate the location for graphic symbols on the display screen.

RATIONALE: Allows the operator to find, mark and move (add, delete) items on the display screen with a minimum of searching and confusion."

(b) Comment. There are two basic methods for positioning a data item. One method is the use of a map background to "eyeball" the desired location and then indicating this position to the system by pointing. The other method is by keyboard entry of the coordinates. The console must give the operator the option of using either method.

(10) Quote and comment.

(a) Quote.

"5. Display a "Marker" symbol (controlled by the operator) to indicate the location where alphanumeric data is to be placed on the display screen.

RATIONALE: The cursor symbol is ineffective for noting the position of alphanumeric data, and therefore a "marker" symbol is needed."

(b) Comment. A marker symbol is required to show the operator where the next added alphanumeric character will appear or which alphanumeric character is to be changed or deleted.

(11) Quote and comment.

(a) Quote.

"6. Display two symbol sizes which conform to conventional symbology (FM 21-30).

RATIONALE: To accommodate the different types of display devices. Display of two symbol sizes allows the capability to transfer displayed data to smaller, remote screens."

(b) Comment. The symbol size should be variable upon operator request. This will allow him to select the size best suited for a particular display scene. However, the console should be designed with one optimum symbol size in mind. The primary constraints are individual symbol legibility and the number of symbols required to be displayed at any one time.

(12) Quote and comment.

(a) Quote.

"7. Highlight updated information until acknowledged by the operator.

RATIONALE: Permits the commander or staff to be updated graphically of current events and denotes the most recent for required review. After review and acknowledgement, the highlighting can be stopped and the correct symbol and color can be inserted on the display. Provides interfacing terminals which permit operation of device away from vicinity of RCC or CCC."

(b) Comment: All data received from other ADP sources should be highlighted upon initial display. At that time, the user should be able to add it to his data base, add it to a data category for review at a later time, or delete it. Blinking is an acceptable method of highlighting. Any other method which is equally as attention getting is acceptable.

(13) Quote and comment.

(a) Quote.

"8. Highlight selected data. (Data is pre-selected by the operator into groupings.)

RATIONALE: Provides easy recognition of critical groupings or symbols."

(b) Comment. The ability to highlight on a permanent basis is best done by color. However, other techniques such as increasing the brightness of the critical symbols is acceptable. The preferred method for temporary highlighting is to cause the critical symbols to blink.

(14) Quote and comment.

(a) Quote.

"9. Display selected characters, words, and lines to aid in the composition of free text message.

RATIONALE: To aid the operator in the composition of fixed format messages."

(b) Comment. Composition of alphanumeric messages (fixed or variable format) is more efficiently done on a separate alphanumeric

display console. The graphic console should not be used routinely to format alphanumeric messages. However, alphanumeric data can be input or called up and displayed on the graphic console as needed.

(15) Quote and comment.

(a) Quote.

"10. Have variable brightness/contrast of displayed information.

RATIONALE: To allow the operator the ability to adjust the screen brightness with relation to the ambient light."

(b) Comment. Brightness control of each color of symbology and the map background should be under user control. This allows the operator to subdue categories of information not of particular interest at the moment in addition to adjusting for the ambient light environment.

(16) Quote and comment.

(a) Quote.

"11. Display from 70 to 140 message formats on call.

"12. Display (under operator control) a message format directory or present key word groupings.

RATIONALE: To aid the operator in the composition of fixed format messages."

(b) Comment. Graphic display consoles should not be used for routine alphanumeric message entry. Composition of alphanumeric messages is more efficiently done on a separate alphanumeric display console.

(17) Quote and comment.

(a) Quote.

"(c) Display module. Display module will be identical to that of the LM10D.

RATIONALE: M10D Display Module meets alphanumeric Input/Output requirements of the analysis console. (See M10D rationale)."

(b) Comment. This module is similar to the alphanumeric display console referred to in subparagraphs (14)(b) and (16)(b) above.

(18) Quote and comment.

(a) Quote.

"(d) Memory Module. Must provide sufficient storage to:

1. Produce and hold a flicker-free display(s).
2. Provide buffering between the data terminal module and other component modules and devices.
3. Permit the Analysis Console to meet the required capabilities.

RATIONALE: Storage requirements are dependent on the design, configuration, and programming used in the Analysis Console."

(b) Comment. Concur if the display technique for the console is one which requires memory to refresh the image (e.g., CRT). However, other display techniques may not require memory integral with the console.

(19) Quote and comment.

(a) Quote.

"(e) Keyboard module will:

1. Permit the use of the Standard ASCII 64 character subset and the use of necessary control characters.

RATIONALE: Provides standardization of characters and permits operator control over placement of symbols and composition of messages."

(b) Comment. The 64-character ASCII set is required. The alphanumeric keyboard layout should be the same as found on standard typewriters.

(20) Quote and comment.

(a) Quote.

"2. Permit the selection of present or dynamic displays by the operator, such as boundaries, enemy ECM and friendly antenna sites, radiation fallout contours, etc.

RATIONALE: Provides starting point for creating and analyzing tactical situation displays and permits the storage of situation displays for later analysis or viewing."

(b) Comment. This requirement is equivalent to the category selection feature discussed in subparagraph 2-4e of this section. This capability is very important.

(21) Quote and comment.

(a) Quote.

"3. Permit the printer module to copy the desired message.

RATIONALE: Provides operator control over the printer and permits hardcopy reproduction of certain messages for use away from the device or for non-computer storage."

(b) Comment. Concur.

(22) Quote and comment.

(a) Quote.

"4. Permit initiation of transmission of data to the computer and other devices.

RATIONALE: Permits operator control over outgoing message transmissions."

(b) Comment. Concur.

(23) Quote and comment.

(a) Quote.

"5. Permit selection of mode of operation (Single or Both Screens).

RATIONALE: Allows the operator to address one display at a time and not have a distracting second display. Also allows interaction between the two displays for greater flexibility."

(b) Comment. The console should have a separate area for displaying certain alphanumeric data. It can be on the same screen as that used for graphic displays, provided it is separate from the graphic display; or it can be on a nearby separate screen. Data displayed in this area will include alphanumeric data associated with a displayed symbol such as its grid coordinates, or free-text remarks pertaining to a displayed symbol. Tabular chart data may also be called up and displayed here. For routine input-output of alphanumeric messages and data, a separate alphanumeric display console should be used.

(24) Quote and comment.

(a) Quote.

"6. Permit composition/entering and editing of alphanumeric and graphic data.

RATIONALE: Permits operator control of message sending, preparation, revision or correction."

(b) Comment. A keyboard is necessary for interaction with the display. Routine messages should be prepared at a separate alphanumeric display console and not at a graphic console.

(25) Quote and comment.

(a) Quote.

"7. Permit positioning of a "marker" symbol.

RATIONALE: The cursor symbol is ineffective for noting the position of alphanumeric data, and therefore a "marker" symbol is needed."

(b) Comment. A marker symbol is required to show the operator where the next added alphanumeric will appear or which alphanumeric is to be changed or deleted.

(26) Quote and comment.

(a) Quote.

"8. Permit positioning of a cursor symbol by a track ball, joy stick, etc., or via input of map coordinate values.

RATIONALE: Requires operator control using the two most common position locators."

(b) Comment. Concur. See subparagraph (9)(b) above for comment.

(27) Quote and comment.

- (a) Quote.
"9. Tab functions to be set manually or under format control.

RATIONALE: Time and labor saving feature designed to enhance the operator's speed and accuracy."

- (b) Comment. This characteristic may not be required on a graphic console keyboard.

(28) Quote and comment.

- (a) Quote.
"10. Permit selective insert/delete of characters, words, and lines (including punctuation and symbols) to aid in the composition of messages.

RATIONALE: Permits operator control of message sending, preparation, revision or correction."

- (b) Comment. This characteristic may not be required on a graphic console keyboard.

(29) Quote and comment.

- (a) Quote.
"11. Permit "read-in" of cursor position (coordinates); drawing of vectors and circles; plotting points, and symbols; deletion generation and relocation of symbols; display of distances; acknowledgement of receipt of a message or display information.

RATIONALE: Applies to graphic data using common symbols and inputs. Permit operator action on received messages (for control purposes)."

- (b) Comment. The functions listed in this characteristic only outline the basic interactive capabilities required of an interactive display console. For a more detailed description of the required interactive capabilities, see subparagraph 2-4e of this section.

(30) Quote and comment.

- (a) Quote.
"12. Provide control over audio/visual signals when pre-selected data categories are displayed, certain parameters are exceeded or a control message received. The operator can manually cancel the indicators by acknowledgement.

RATIONALE: Certain data is too important to rely on the highlighting capability. The specified data, the indicators, and the parameters are under operator control because each A.C. user will have a different primary purpose."

(b) Comment. Concur.

(31) Quote and comment.

(a) Quote.

"13. Start (initiate) hardcopy of a message.

RATIONALE: Permits operator control if overriding of programmed functions is required."

(b) Comment. Concur. A specific pushbutton (e.g., PRINT) could be used.

(32) Quote and comment.

(a) Quote.

"(f) Control Module will:

1. Provide for activation of audio and visual signals by operator or preselected categories.

RATIONALE: See Characteristic c(6)(e)12."

(b) Comment. Some audio and visual signals will require automatic system activation (e.g., highlighting of a symbol newly input from TOS).

(33) Quote and comment.

(a) Quote.

"2. Provide separate control over brightness/contrast on the map background and the computer driven data.

RATIONALE: Environmental changes (sunlight, darkness) require varying display intensities to meet readability criteria."

(b) Comment. Concur. Brightness control of each color of dynamic symbology and the map background should be under user control. This will allow the operator to subdue categories of information not of particular interest at the moment. It will also allow him to adjust for the ambient light environment.

(34) Quote and comment.

(a) Quote.

"3. Provide for control of traffic between the modules of the AC.

RATIONALE: Permits orderly interfacing between the modules that make up the AC."

(b) Comment. No comment.

(35) Quote and comment.

(a) Quote.

"4. Provide for selection of preset dynamic displays and capability to alter the displays via operator control.

RATIONALE: Provides immediate correctional capabilities to the operator. The operator must only correct information or data he originated and/or reviews before entry to data base."

(b) Comment. The ability to store and to display historical data is a requirement. The ability to modify a recalled scene and re-store the modified scene is also a requirement.

(36) Quote and comment.

(a) Quote.

"5. Provide for call-up of a message format directory (of 100 to 200 formats) and, at request, call up any message format in that directory.

RATIONALE: Gives user ability to rapidly compose messages for transmission. By reducing messages composition time, TOS will require fewer AC's and therefore, fewer users, resulting in a faster response to queries."

(b) Comment. Routine alphanumeric input or output is better done from a separate alphanumeric display console; however, the graphic console should have this capability.

(37) Quote and comment.

(a) Quote.

"6. Provide for call-up of key word groups, priority groupings, functional areas or any other data configuration and display the subset(s) of those groupings on request.

RATIONALE: Required to provide user with access to the data banks. Allows user to reference lists to help in preparing queries and SRI's."

(b) Comment. If the data referred to in this requirement is alphanumeric, the comment in subparagraph (36)(b) above applies.

(38) Quote and comment.

(a) Quote.

"7. Provide for call-up of a list of abbreviations to be used in composing messages or displays.

RATIONALE: See Characteristic c(6)(f)5."

(b) Comment. See comment in subparagraph (36)(b) above.

(39) Quote and comment.

(a) Quote.

"8. Provide capability for updating symbology as the new symbols evolve from the military application of automation.

RATIONALE: Needed for readability of AC and adjustment of TOS to future developments, should new symbols evolve."

(b) Comment. The operator must have the ability to create military branch duty and graphic symbols that are not contained in the system symbol library. The operator should be able to manipulate a created symbol in exactly the same manner as a symbol in the permanent symbol library.

(40) Quote and comment.

(a) Quote.

"9. Provide for storage of any display (operator specified display) for later re-display.

RATIONALE: Permits user to save a display and eliminates later recreation, thus saving the operator's time. Storage can be done locally or at the RCC."

(b) Comment. The ability to store and to display historical data is a requirement. The ability to modify a recalled scene and re-store the modified scene is also a requirement.

(41) Quote and comment.

(a) Quote.

"10. Provide local correction of data and on command, alter the data base.

RATIONALE: Needed for system/data base protection (against 9 operator errors)."

(b) Comment. Concur.

(42) Quote and comment.

(a) Quote.

"11. Have the capability of both screens to be separately addressable by the operator.

RATIONALE: To allow the user to review and/or compose two separate messages simultaneously."

(b) Comment. The rationale should read: "To allow the user to monitor the tactical situation while interacting with alphanumeric data.

(43) Quote and comment.

(a) Quote.

"12. Control registration of computer generated data with the map.

RATIONALE: Requires the display to hold and maintain accuracies of read-in positions within an acceptable limit."

(b) Comment. Concur.

(44) Quote and comment.

(a) Quote.

"(g) Power Unit Module will be similar to that found in the MIOD.

RATIONALE: To allow for standardization of equipment within the system through a standardized power module."

(b) Comment. No comment.

(45) Quote and comment.

(a) Quote.

"(h) Printer Module will be identical to that found in the MIOD.

RATIONALE: To allow for standardization of equipment within the system through a standardized printer module."

(b) Comment. See subparagraph 2-4e of this section for additional printer requirements.

(46) Quote and comment.

(a) Quote.

"(i) Data Terminal Module. Data Terminal Module provides for:

1. Transmission and reception of messages from the RCC thru either wire or radio mediums.

2. Alternate transmission links to the CCC or other RCC's when the primary RCC is down.

3. Full Duplex Operation.

4. Meeting requirements for data terminals (DT).

RATIONALE: Since an input/output device is used in the field and subject to destruction, it must use all available communications to provide flexibility and reliability. Full duplex is needed to meet the response time and eliminate the need for extra AC devices."

(b) Comment. No comment.

d. Revision and update of the MN for TOS. The requirements in the MN for TOS are in need of revision and update for several reasons.

(1) The findings described in paragraph 2-3 of this section do not support the envisioned role for the group display device and the analysis console that is implied in the MN for TOS.

(2) The requirements in the MN for TOS are incomplete. In addition, some listed requirements are not fully explained while others are not realistic. Furthermore, the FM 116 experimentation surfaced requirements which were not envisioned when the requirements in the MN for TOS were written.

(3) The listing of the requirements in the MN for TOS by functional module is confusing. Some of the modules listed have no apparent corresponding physical device (i.e., the control module for the analysis console). A better way to organize the requirements is to specify them by physical device (e.g., group display output device, interactive graphic display console). The requirements for each device can be categorized by display characteristic (i.e., viewability of displayed data; placement accuracy and display completeness; map backgrounds; timeliness and ease of use; and reliability, availability, and maintainability).

2-6. Specific Automated Display Requirements.

a. General.

(1) This paragraph states specific requirements for an automated display system. The requirements apply to a display system for use by commanders, intelligence (G2), and operations (G3) staff personnel in division TOC's.

(2) The requirements are extracted from the narrative discussion in paragraphs 2-3 and 2-4 of this section. No new data is presented. The requirements and supporting rationale are individually identified and grouped by device (i.e., interactive graphic display console, group display output device, etc.). The list of requirements collectively gathers all the requirements for each device discussed in paragraphs 2-3 and 2-4, and provides a ready reference for the interested reader. Where applicable, each requirement and rationale is identified as belonging to one of five functional categories:

- (a) Viewability of displayed data (VDD).
- (b) Placement accuracy and display completeness (PADC).
- (c) Map backgrounds (MB).
- (d) Timeliness and ease of use (TEU).
- (e) Reliability, availability, and maintainability (RAM).

(3) The words "must" or "required" are used to indicate essential requirements, and the words "should" or "desirable" are used to denote requirements which are considered highly desirable but not essential.

(4) Since this paragraph is only a reorganization of the requirements discussed in paragraphs 2-3 and 2-4 of this section, the reader may, if he desires, proceed directly to section III. Section III is an evaluation of how well the three different automated display systems met the specific requirements.

b. Automated display system (general).

(1) Requirement and rationale number 1.

(a) Requirement 1. An automated display system must satisfy different users in a TOC.

(b) Rationale. The division G2 and the G3 are considered separate users, since they have different information requirements. The requirements which must be met by the display system vary depending upon the user. Thus, configuration of the components required to satisfy different users also varies.

(2) Requirement and rationale number 2.

(a) Requirement 2. As a minimum, an automated display system must have two basic components. The first is a local display processor which allows the receipt, storage, retrieval, display, and manipulation of data. The processor also controls the operation of the other hardware components in the display system. The second basic hardware component is the interactive graphic display console.

(b) Rationale. The functions that the processor must perform dictate that it be separate from the TOS central computer and that it be dedicated solely to the operation of the display system. It is inefficient and impractical to require the TOS central computer to do the display data processing as well as control all the devices of the system. The problem is compounded when a number of display systems are linked to TOS, thus multiplying the total number of devices to be controlled. The separate display processor is not only more user responsive, but it also acts as the single point of contact for interaction between TOS and the display system. The display processor also facilitates "stand-alone" operation of the system and provides a built-in CONOPS benefit. The interactive graphic display console is the primary user device for display of, and interaction with, computer stored data. The console features which make this possible are a display surface dedicated to the presentations of displays for a specific user; the controls, such as keyboard, joystick, and light pen with which the user can recall, create, modify, or delete displays; and a positive visual feedback on the display surface which allows the user to monitor display manipulation.

(3) Requirement and rationale number 3.

(a) Requirement 3. Software should receive first priority in the development of an automated display system.

(b) Rationale. This does not mean that initial emphasis is to be placed on developing detailed logic flow diagrams. Rather, detailed answers should be obtained for the question: "What procedures should be designed to permit the user to meet his requirements with maximum ease?". The answers to the question will define the software required. The software will provide vital guidance concerning hardware type and configuration. This approach defines the user's needs and identifies the software required to meet these needs before the hardware is procured. The logic of this approach is better than the common practice of buying the hardware and then designing software to fit the hardware. Additionally, software comprises the bulk of system development cost, and therefore, should receive priority.

(4) Requirement and rationale number 4.

(a) Requirement 4. User comments must be actively solicited by the hardware and software designers in all stages of system development.

(b) Rationale. The user is the most important element in the successful design of an automated system. Violation of this requirement could result in the fielding of a system which may be rejected in favor of the current manual operation because it does not do what is wanted, is too complicated to operate, or is simply too cumbersome.

(5) Requirement and rationale number 5.

(a) Requirement 5. An automated display system is required to operate in a field environment, under all weather conditions. It must perform the display functions associated with mission accomplishment for command and staff personnel in a tactical operations center. Key components of the system are required to operate continuously (24 hours per day, 7 days per week) for varying periods. The system moves whenever the tactical situation dictates that the TOC must displace. The system must meet high standards of reliability, availability, and maintainability. The equipment must be rugged, compact, lightweight, and it must not degrade mobility of the TOC. The operational availability of the system should approach 100 percent. This should take into account both hardware and software caused failures.

(b) Rationale. The display functions of an automated display system involve the input, processing, manipulation, storage, retrieval, display, and output of data contained in TOC working files such as the current friendly and enemy situation files. The inability to perform one or more of the above functions even for short periods (e.g., 10 to 20 minutes) degrades system performance, could affect mission accomplishment, and is undesirable.

(6) Requirement and rationale number 6.

(a) Requirement 6. Procedures must be provided to facilitate continuity of operations during varying degrees of system performance degradation and during system displacement.

(b) Rationale. The TOC must continue to operate during total or partial system failure and during displacement.

c. Display processor.

(1) Requirement and rationale number 1 (RAM).

(a) Requirement 1. The display processor is required to operate 24 hours a day, 7 days per week, for varying periods.

(b) Rationale. The display processor controls the operation of an automated display system. The system components which it controls become inoperable whenever the processor fails. Consequently, the processor's reliability, availability, and maintainability requirements are the most stringent.

(2) Requirements and rationale number 2 (RAM).

(a) Requirement 2. If it is necessary to return to full operation when preventive maintenance is being performed, the preventive maintenance must be completed or terminated so that full operation is restored within 15 minutes.

(b) Rationale. Preventive maintenance actions are normally scheduled during periods of expected decreased activity in the TOC. However, if activity should pick up, it must be possible to complete or terminate the preventive maintenance so that full operation is restored within 15 minutes. Any time longer than this could severely hamper continuity of operations and could force the user to revert to some other method of operation to replace functions performed by the system.

(3) Requirement and rationale number 3 (RAM).

(a) Requirement 3. The processor must be designed in such a manner that any unscheduled maintenance action takes no longer than 15 minutes. This time is measured from the moment it is first sensed that the system is down until the system is again operational. The time includes fault detection, isolation, and correction as well as administrative and supply delays.

(b) Rationale. Any time longer than 15 minutes could severely hamper continuity of operations and could force the user to revert to some other method of operation to replace functions performed by the system.

d. Interactive graphic display console (individual display).

(1) Requirement and rationale number I (VDD).

(a) Requirement I. The console must be able to display the 64-character ASCII set; the FM 21-30 symbols listed below; symbology added to the symbol generator by the user; circles; ellipses; and free-hand graphics such as symbols for boundaries and axis of advance. The following symbols should be a part of the permanent symbol generator. FM 21-30 illustrates each symbol and provides examples of the use of the symbols.

Military Unit Symbols

HEADQUARTERS
CENTER OF MASS
TRAIN

NOTE: Military unit symbols must be displayed as actual or proposed. In addition, they must denote whether the represented unit is a task force.

Branch Duty Symbols

AIRBORNE	ARMOR	ENGINEER
AIR DEFENSE ARTILLERY	AVIATION	INFANTRY
AIRMOBILE	CAVALRY	MAINTENANCE
ANTITANK	CHEMICAL	PSYCHOLOGICAL OPERATIONS
FIELD ARTILLERY	ENGINEER, BRIDGE	SIGNAL
		TRANSPORTATION

Graphic Symbols

OBSERVATION POST	AMMUNITION SUPPLY POINT, ALL TYPES (combat service support installation)
COORDINATING POINT	AID STATION (combat service support installation)
MINE, ANTITANK	
MINE, ANTI PERSONNEL	
POL. POINT, GROUND (combat service support installation)	

Line-Type Graphic Symbols

SOLID LINE
TRENCH, BASIC SYMBOL
WIRE, CONCERTINA, SINGLE

DASHED LINE
TANK OBSTACLE, TYPE UNSPECIFIED
LINE OF CONTACT (defensive frontline
trace)

(b) Rationale. Tactical situation displays require this symbology as a minimum. The selection of the symbols for inclusion in the permanent symbol library is based on their expected frequency of use.

(2) Requirement and rationale number 2 (VDD).

(a) Requirement 2. A minimum of three colors is required. Three colors allow friendly, enemy, and control measure symbols to be color coded. Four to six colors are desirable. Color selection must be based upon obtaining a high degree of contrast in relation to the map backgrounds the symbols will be displayed upon.

(b) Rationale. Distinction of friendly symbols from enemy symbols is possible on a one color display by means of shape coding. However, the enhanced ability of the user to readily distinguish between color coded enemy, friendly, and boundary data items at a glance is required to preclude delay in their discrimination. Additional colors over and above three allow the highlighting of selected symbols or the color coding of particular categories of information. The selected colors must stand out from the map background data. This enhances dynamic symbol legibility.

(3) Requirement and rationale number 3 (VDD).

(a) Requirement 3. The operator should be able to easily identify any symbol on the display while working under normal office lighting (70 foot-candles at desk top level). Full legibility with desk lamps only at each work space is marginally acceptable.

(b) Rationale. The console will generally be located near other staff activities which require at least 70 foot-candles of ambient light on their work area to reduce eyestrain and fatigue. Also, the console operator will be required to read printed or handwritten material during the course of his duties.

(4) Requirement and rationale number 4 (VDD).

(a) Requirement 4. The symbol size should be variable upon operator request. However, the console must be designed with one optimum symbol size in mind.

(b) Rationale. The capability to adjust display symbol size is desirable but not absolutely necessary. It would allow the operator to select the size symbol best suited for a particular display. One optimum symbol size is required to facilitate the console design.

(5) Requirement and rationale number 5 (VDD).

(a) Requirement 5. The console display area must be large enough to display a tactical situation (maximum of 75 military unit symbols for a division) with a minimum amount of symbol clutter, but it must not be so large that it causes the operator undue eyestrain or head movement.

(b) Rationale. For a given distance from the display surface, there is a limit on how much area an individual can see without undue eye or head movement. Operator eye and head movement are influenced by two factors: screen size and operator distance from the screen. It is assumed that the screen will be located within arm's reach of the operator.

(6) Requirement and rationale number 6 (VDD).

(a) Requirement 6. The displayed symbology must not have any discernible flicker.

(b) Rationale. Flicker causes eyestrain.

(7) Requirement and rationale number 7 (VDD).

(a) Requirement 7. The brightness of each color of dynamic symbology and each color representing a map data feature should be controllable by the console operator. As a minimum, the operator must be able to vary the overall brightness of the dynamic symbology and the overall brightness of the map background.

(b) Rationale. Individual color brightness control allows the operator to subdue categories of information which at a particular moment are not of significant interest or which detract from other information. Overall brightness control allows adjustment to suit the ambient light environment.

(8) Requirement and rationale number 8 (VDD).

(a) Requirement 8. Fully automatic declutter (offset) without affecting currently displayed symbols upon initial display (regardless of whether manually created or received from TOS) of any symbol for a military unit, spot report, sensor locations, etc., is required. The declutter lines must be directly attached to the symbol.

(b) Rationale. The operator should not be burdened with having to manually declutter newly entered symbols. Currently displayed symbols should not be affected. This prevents the operator's perspective from being upset.

(9) Requirement and rationale number 9 (VDD).

(a) Requirement 9. The operator should be able to cause a complete, automatic redeclutter of the display. The redeclutter should relocate symbols based upon the criteria of the shortest possible declutter lines and no symbol overlap. Each symbol should be considered equally. Priority of entry should have no effect.

(b) Rationale. The declutter of symbols in the display may at times become very unsightly due to long declutter lines. Automatic redeclutter allows the operator to quickly obtain the best possible display.

(10) Requirement and rationale number 10 (VDD).

(a) Requirement 10. Co-located military unit headquarters must be automatically stacked before being decluttered upon initial display.

(b) Rationale. Stacking aids the user in rapidly distinguishing headquarters which are co-located.

(11) Requirement and rationale number 11 (PADC).

(a) Requirement 11. Data items superimposed against a map background on the interactive graphic display console must appear to be no more than 100 meters from the specified map location. This 100-meter limit applies for any method of data item location: keyboard coordinate entry, coordinates transmitted from an outside ADP source, points transmitted from the map overlay input device, or direct entry by pointing to the location on the console display. The limit applies regardless of the size of the area of coverage being viewed.

(b) Rationale. Current manual procedures for plotting symbols against the 1:50,000 scale standard military map have an inherent plotting accuracy. The average individual updating a map in the TOC will, with few exceptions, position a given symbol within 100 meters of its specified map location. Most display users in the operations and intelligence sections of the TOC are concerned with the effect that symbol placement accuracy has on the evaluation of the positional relationships of the displayed symbols. While some users may require greater accuracy, the inherent accuracy of manual map posting is acceptable to most users in the TOC.

(12) Requirement and rationale number 12 (PADC).

(a) Requirement 12. Exact entry coordinates of data item locations entered by keyboard or by coordinates from an outside ADP source must be displayed upon request.

(b) Rationale. The user should always have the option of referring to the coordinate that originated a data item's location.

(13) Requirement and rationale number 13 (PADC).

(a) Requirement 13. For data items entered by pointing, as well as locations entered via the map overlay input device, the coordinate provided in reply to a query must be no more than 100 meters from the data item's apparent map location.

(b) Rationale. The input of data items by either of these methods should meet the 100-meter accuracy requirement.

(14) Requirement and rationale number 14 (PADC).

(a) Requirement 14. Data items located with single points must be completely displayed if the point is inside the selected area of coverage. This may require the automatic decluttering of the data item to ensure that the entire item appears in the area of coverage such as when a military unit is at the top edge of the background. If any part of a multiple-point data item is in the selected area of coverage, that part within the area of coverage must be displayed. The part to be displayed must include all points of the data item up to and including those at the intersection of the item with an edge of the map background.

(b) Rationale. An incomplete display is unacceptable.

(15) Requirement and rationale number 15 (PADC).

(a) Requirement 15. Incoming messages (from an outside ADP source) which contain branch duty symbols not in the system's permanent branch symbol library, must display at least the first four alphanumeric characters of the branch duty designation (from the incoming messages) inside the rectangle where the branch duty symbol normally appears.

(b) Rationale. This precludes the requirement for the system to contain all FM 21-30 branch duty symbols in its permanent library. Many branch duty symbols are used so seldom that their inclusion in the library would be very inefficient from a software and hardware design stand-point.

(16) Requirement and rationale number 16 (MB).

(a) Requirement 16. An interactive graphic display console must be capable of displaying map backgrounds for the three uses described below:

1 Comprehension of the overall situation. For this purpose the user is not interested in being able to read all detail on the standard military topographic map, but he uses the map to provide general orientation for the superimposed symbology.

2 More detailed inspection of the terrain at or in the vicinity of a superimposed symbol or symbols. In this case the user is interested in a more exact relationship of the symbols to the terrain.

3 Terrain analysis without superimposed symbology. For example, when selecting the best terrain upon which to establish a defense or when planning a route of movement, the user wants to view the map background with no superimposed dynamic symbology.

(b) Rationale. Map backgrounds are used in the TOC for the three purposes described. A map background is an essential part of any tactical situation display. The display of the situation is relatively useless unless the symbology is superimposed upon a map background, thereby orienting the symbology to the terrain.

(17) Requirement and rationale number 17 (MB).

(a) Requirement 17. Map backgrounds based on the UTM grid system will normally be displayed on the console. However, the console should be able to accommodate other military grid systems. The UTM grid system requires that the console be able to display areas of coverage which include the junction of two or more map sheets and the junction of two or more 100,000-meter grid zones.

(b) Rationale. Maps having the UTM grid system are used in TOC's. Situation maps are frequently made up of two or more adjacent map sheets.

(18) Requirement and rationale number 18 (MB).

(a) Requirement 18. The console must be able to display an area of coverage large enough to permit superimposing dynamic symbology for most user tactical situations displays. User data indicates that an area at least 50 kilometers by 50 kilometers is required for an overall situation display of an armored or mechanized division. The console screen must be designed to provide this area of coverage.

(b) Rationale. The user must have a map background area of coverage of sufficient size to depict tactical situation displays.

(19) Requirement and rationale number 19 (MB).

(a) Requirement 19. It is assumed that the screen is within arm's reach of the operator. The operator must view the entire screen image area from this distance without undue eye and head movement.

(b) Rationale. The arm's reach distance makes any symbol on the screen convenient to point at or otherwise interact with. Minimal eye and head movement minimizes operator eyestrain and fatigue.

(20) Requirement and rationale number 20 (MB).

(a) Requirement 20. When the user changes the area of coverage displayed on the screen, user specified dynamic symbology in the new area of coverage must be automatically displayed on the new area at the appropriate map locations. This requirement applies if the new area is a magnification of a small portion of the old area, if it includes all or a portion of the old area, or if it does not include any portion of the old area.

(b) Rationale. This allows the user to go from one background area to another without having to recreate the tactical situation display.

(21) Requirement and rationale number 21 (MB).

(a) Requirement 21. Map backgrounds displayed on the console screen must be fully legible under the ambient light specified in requirement 3 above for dynamic symbology legibility. Full legibility is defined as the ability of the operator to easily identify each and every item of map data displayed.

(b) Rationale. A data item which is not legible is of no informational value.

(22) Requirement and rationale number 22 (MB).

(a) Requirement 22. The console operator should be able to vary the brightness of each color representing a map feature (e.g., roads, vegetation, rivers). He must, as a minimum, be able to vary the overall brightness of the map background.

(b) Rationale. This capability, combined with the ability to independently vary the intensity of the dynamic symbology, allows the user to concentrate on dynamic symbology or map data as desired.

(23) Requirement and rationale number 23 (MB).

(a) Requirement 23. Ideally, the user should be able to obtain the desired area of background coverage by providing the system with the coordinates of any two diagonal corner points.

(b) Rationale. This allows the user to tailor the area to the particular situation.

(24) Requirement and rationale number 24 (MB).

(a) Requirement 24. The operator must have the option of numbering or otherwise identifying a map background area which he defines by two diagonal corner points.

(b) Rationale. This allows the operator to conveniently recall specific backgrounds.

(25) Requirement and rationale number 25 (MB).

(a) Requirement 25. Ideally, the user should be able to tailor the level of map detail to the situation by being able to display specific map features (grid lines, roads, contours, rivers, etc.) individually, or in combination, for the defined area of coverage. For each specific map feature, the user should be able to select more or less detail (e.g., grid lines 1, 5, or 10 kilometers apart; primary roads only, or primary and secondary roads; or contour intervals of 100, 200, or 500 meters).

(b) Rationale. This ability, along with the ability to specify a map area of coverage by two diagonal corner points, permits the user to tailor a map background for any situation.

NOTE: A state-of-the-art technique which can be employed to display map data is the use of discrete on-line backgrounds, selectively retrievable, which contain variation in both area of coverage and level of map detail. *This is not the optimum solution* but may have to be accepted until technology permits attainment of the ideal specified in requirements 23 and 25 above. If discrete-on-line backgrounds are employed, requirements 26 through 32 apply.

(26) Requirement and rationale number 26 (MB).

(a) Requirement 26. The available backgrounds must be on-line and retrievable within 15 seconds. The capability to retrieve and display a background within 5 seconds is highly desirable. Additionally, the user must be able to add to or delete from the number of available backgrounds.

(b) Rationale. Rapid background changes provide flexibility. Fifteen seconds is the maximum time that a user can be expected to wait without inconvenience for the retrieval of a background.

(27) Requirement and rationale number 27 (MB).

(a) Requirement 27. Registration of a new background (i.e., defining for the system the limits of the area) must require the operator to only point at and input the UTM coordinates of any two grid intersections diagonally located in relation to each other. The background must not have to be exactly horizontal, vertical, or centered. Once registered, the background must be available for display without re-registration each time it is retrieved.

(b) Rationale. This provides the user maximum ease of use when registering a discrete map background.

(28) Requirement and rationale number 28 (MB).

(a) Requirement 28. Backgrounds to be used for display of the *overall* division situation must have an area of coverage no less than 50 kilometers by 50 kilometers.

(b) Rationale. The required area of coverage for portraying most division tactical situations is at least 50 kilometers by 50 kilometers.

(29) Requirement and rationale number 29 (MB).

(a) Requirement 29. The map data on maps used for comprehension of the *overall* situation (requirement 16) must be enhanced or highlighted. Letters and numbers may have to be larger than those found on the standard military topographic map.

(b) Rationale. All detail on displayed map backgrounds must be fully legible.

(30) Requirement and rationale number 30 (MB).

(a) Requirement 30. Backgrounds with selected combinations of map detail are required.

(b) Rationale. Maps with varying levels of map detail provide flexibility.

(31) Requirement and rationale number 31 (MB).

(a) Requirement 31. Background coverage overlap must be provided.

(b) Rationale. This allows for continuity of background coverage when changing background areas.

(32) Requirement and rationale number 32 (MB).

(a) Requirement 32. Backgrounds which magnify smaller portions of the 50-kilometer by 50-kilometer backgrounds must be provided. A sufficient number (four to nine may be sufficient depending upon the size of the screen and the map area of coverage) of blowups should be available so that the composite area of each 50-kilometer by 50-kilometer background can be shown in magnified form. The blowups need not overlap but must contain no less detail than that found on the 1:50,000 scale topographic map. When the blowups are displayed, they must be fully legible.

(b) Rationale. These blowups provide the greater level of map detail necessary for a more detailed inspection of the map background data either with or without superimposed symbology.

(33) Requirement and rationale number 33 (TEU).

(a) Requirement 33. The console operator must be able to add, delete, correct, move, and declutter (offset) any tactical situation display data item. Instantaneous visual feedback of the operator's actions is required for all manipulations.

(b) Rationale. Without the ability to manipulate data items, the console would not be an interactive device. Console ease of use is greatly enhanced by the instantaneous visual feedback of all manipulations.

(34) Requirement and rationale number 34 (TEU).

(a) Requirement 34. The console operator must have some means for positioning newly created or moved data items. There are two basic methods for positioning a data item. One method is the use of a map background to "eyeball" the desired location. This position is then indicated to the system by pointing. The other method is by keyboard entry of the coordinates. The console must give the operator the option of using either method. The first method is generally used when the exact location is not critical or when the position needs to be determined through map inspection. Coordinate entry is used for those items with specific coordinates. Coordinate entry must not require grid zone designation (entry of grid zone designation should be optional). Additionally, it must allow a 4-, 6-, or 8-digit entry depending upon operator preference. The map currently displayed can be used by the system to interpret the coordinates entered by the operator.

(b) Rationale. Operator interaction with a tactical situation display requires a means for positioning newly created or moved items. Coordinate entry in accord with operator preference enhances system ease of use.

(35) Requirement and rationale 35 (TEU).

(a) Requirement 35. Some means for indicating which item in the display is to be deleted, corrected, moved, or decluttered is required. The preferred method is to point at the item. Ideally, the operator should be able to indicate which item is to be manipulated by touching it with his finger, provided the technology, cost, and complexity of implementation support this method. Other less desirable (but state-of-the-art) methods for pointing are light pens and trackball- or joystick-controlled cursors.

(b) Rationale. Data manipulation requires a means for indicating which data item is to be manipulated.

(36) Requirement and rationale number 36 (TEU).

(a) Requirement 36. The system must lead the operator through each key step of the operating procedure. For example, if function pushbuttons are used, the system could be programmed to light appropriate pushbuttons to show the operator his choice of alternatives at each step in the procedure. In this case, the pushbuttons should be in a color selected to identify them as available alternatives and to differentiate them from pushbuttons which are merely activated.

(b) Rationale. This feature reduces procedural errors and the amount of instruction required for operator training.

NOTE: The following procedure requirements (requirements 37 through 54) are presented as a guide rather than as firm requirements. The procedures serve two purposes. The first purpose is to outline the interactive capabilities that automated display systems must have to effectively assist the user in meeting his information display requirements. The second purpose is to illustrate the degree of simplicity that each procedure should have. The two primary factors which must be considered in the design of operating procedures are the ease with which the procedures can be learned and the ease with which they can be used. It will be noted that the procedures use function pushbuttons. The preference for pushbuttons is not intended to mean that pushbuttons are to be used for every step in each procedure presented. In fact, the total number of pushbuttons required may be excessive if pushbuttons are used exclusively for the implementation of all the procedures presented. Pushbuttons merely provide a convenient means of standardizing the description of the procedures. A human engineering study is required to determine the best design for incorporating the procedures to be used.

The optimum design may involve the use of pushbuttons in conjunction with other techniques. For example, pushbuttons could be used when the steps in a procedure are few or to initiate the key steps of a long procedure. "Menu selection" or some other appropriate technique could be employed (after the step is initiated by a pushbutton) if the use of pushbuttons for subsequent procedure steps would be impractical or inefficient when considered in the context of the overall design. The pushbuttons used in the description of the procedures can be illuminated and are either on (lit) or off depending on their state before the operator touches them. This gives the operator positive feedback that his interaction has been sensed by the computer. It also provides a ready reference as to which pushbuttons are currently activated. In addition, the computer is able to light or turn off any and all pushbuttons. This feature assists in leading the operator through the key steps of an operating procedure by allowing the computer to indicate (by blinking or color change) the possible pushbutton selections in an operational sequence. Any technique used in lieu of pushbuttons should also lead the operator through the key steps of the operating procedures.

(37) Requirement and rationale number 37 (TEU).

(a) Requirement 37. Data item creation should require a procedure similar to that listed below:

- 1 Press the CREATE data item pushbutton.
- 2 Select the categories the data item will be a member of by pressing the appropriate category pushbuttons. (See requirement 47 below.)
- 3 Press one of three data type pushbuttons: A/N, MILITARY SYMBOL, or GRAPHIC.
- 4 Press the desired color pushbutton (e.g., RED for red).
- 5 Point to the desired location on the screen or type in the coordinate location. (There should be visual feedback whenever a coordinate is being typed.)
- 6 Create the desired item by using the procedure discussed in the following subparagraphs for that data type.
 - a Alphanumerics.
 - (1) Alphanumerics are most effectively created with the ASCII keyboard. A special key for the coordinate position dot associated with some alphanumerics (e.g., • TANK, • TRUCK) must be provided, since the

ASCII period does not stand out and its location is generally not precise. A marker must appear on the screen to indicate to the operator the position of the next character to be added.

(2) The ability to space left, right, up, and down is required to allow the operator to format the data item to suit his needs. He must also be able to backspace in order to make corrections.

b Military unit symbols.

(1) In creating military unit symbols, pushbuttons should be used to select a headquarters, center of mass, or trains symbol. If the symbol is to depict a proposed or task force symbol, the appropriate pushbuttons should be pressed. Branch duty symbol selection is then accomplished by pressing a pushbutton. The following branch duty symbol pushbuttons should be provided:

AIRBORNE	ARMOR	ENGINEER
AIR DEFENSE ARTILLERY	AVIATION	INFANTRY
AIRMOBILE	CAVALRY	MAINTENANCE
ANTITANK	CHEMICAL	PHYCHOLOGICAL
FIELD ARTILLERY	ENGINEER, BRIDGE	OPERATIONS
TRANSPORTATION		SIGNAL

(2) At least 10 additional pushbuttons must be provided for operator created branch duty symbols. (See requirement 42 below for creation procedures.) The operator must have the option of superimposing at least two branch symbols (e.g., armor, infantry) in the creation of a military unit symbol. An easily identifiable point such as the lower left corner of the flag should be established as the location of flag symbols with no staffs. The system should lead the operator through the addition of the left and right identifications and the echelon. A marker must advance automatically to each of these locations. Each location must allow for the entry of up to four ASCII characters.

c Graphics.

(1) The creation of graphic items such as boundaries, frontline traces, trench lines, and freehand symbols by a series of short line segments must be possible by both pointing and coordinate location. The procedure should require only that the operator specify the points of inflection, the end point, and the type graphic (e.g., solid line, dashed line, trench symbol) being created. The following line-type graphic symbol pushbuttons should be provided:

SOLID LINE	DASHED LINE
TRENCH, BASIC SYMBOL	TANK OBSTACLE, TYPE UNSPECIFIED
WIRE, CONCERTINA, SINGLE	LINE OF CONTACT (defensive front-line trace)

At least two additional pushbuttons must be provided for operator created line-type graphic symbols. (See requirement 44 below for creation procedures.) The system should automatically connect the points with the line type selected. In the case where pointing is used to specify coordinate location, it is desirable to have a rubber band line segment effect which allows the operator to see where the line will be before fixing the inflection point.

(2) The creation of circles or ellipses should be indicated to the system by pressing the CIRCLE or ELLIPSE pushbutton. The operator then indicates the radius or major and minor axes by pointing to their particular locations on the screen. A continuously visible size variation ability at this point is desirable.

(3) The creation of individual graphic symbols such as mines and control points should use pushbuttons for the selection of the desired symbol. The following graphic symbol pushbuttons should be provided:

OBSERVATION POST
COORDINATING POINT
MINE, ANTITANK
MINE, ANTI PERSONNEL
POL POINT, GROUND (combat service support installation)

AMMUNITION SUPPLY POINT, ALL TYPES
(combat service support installations)
AID STATION (combat service support installation)

At least five extra pushbuttons must be provided for operator created individual graphic symbols. (See requirement 43 below for creation procedures.) The coordinate location of the symbols will be assumed to be at their center.

7 If the operator desires to start over at any point, he should only have to press the ABORT pushbutton. This returns the console to the operational state it was in before the CREATE pushbutton was pressed.

8 Press the COMPLETE pushbutton. This should leave the previously selected CREATE, category, symbol type, and color pushbuttons lit. The operator can then create several data items of the same type without reselection. He should also have the option of reselecting categories, symbol type, or color at any time before the COMPLETE pushbutton is pressed. The CREATE pushbutton will remain activated until the operator turns it off.

(b) Rationale. Procedures must require a minimum amount of operator effort and training.

(38) Requirement and rationale number 38 (TEU).

(a) Requirement 38. The procedure for correcting data items in a display should be similar to that listed in the following subparagraphs.

- 1 Press the CORRECT data item pushbutton.
 - 2 Point out the item to be corrected. (Visual feedback as to which symbol was selected should occur.)
 - 3 Correct the symbol by using the procedure discussed in the following subparagraphs for that type item. If a color change is all the operator desires, he should only have to press the appropriate color pushbutton.
 - a Alphanumerics. Alphanumeric correction must allow for advancing or backspacing to any character in the data item. A marker must indicate which character will be changed if an ASCII key is pressed.
 - b Military unit symbols. The procedure for military unit symbol correction must also use a marker to indicate to the operator which portion of the symbol the system is ready to change. The marker under operator control either advances or backspaces through the parts which make up the data item (flag, branch, identifications, echelon). This allows him to change any or all parts of the item.
 - c Graphics. Line segment graphic item correction is much like the correction of alphanumerics and military unit symbols as a marker indicates to the operator which inflection point the system is ready to change. The graphic type (i.e., solid line, trenches) is also subject to change. Correction of circle radiiuses or ellipse major and minor axes requires indicating the new radius or axis by pointing at its location on the screen. Correction of individual graphic symbols (i.e., mines, control points) should only require pressing the pushbutton for the desired symbol.
 - 4 If the operator desires to start over again he should only have to press an ABORT pushbutton.
 - 5 Press the COMPLETE pushbutton. The console should return to the operational state which existed prior to pressing CORRECT.

(b) Rationale. Procedures must require a minimum amount of operator effort and training.

(39) Requirement and rationale number 39 (TEU).

(a) Requirement 39. The procedure for moving a data item applies to all data types except line segment graphics and should be similar to the procedure listed below:

 - 1 Press the MOVE data item pushbutton.
 - 2 Point out the item to be moved. (Visual feedback as to which item was selected should occur.)
 - 3 Point to the desired new location on the screen or type in the coordinate location. (There should be visual feedback of the coordinate being typed.)

4 If the operator desires to start over at any point he should only have to press the ABORT pushbutton.

5 Press the COMPLETE pushbutton. The console should return to the operational state which existed prior to pressing MOVE.

(b) Rationale. Procedures must require a minimum amount of operator effort and training.

(40) Requirement and rationale number 40 (TEU).

(a) Requirement 40. The procedure for decluttering (offsetting) a data item applies to all data types except graphics and should be similar to the procedure listed below:

1 Press the DECLUTTER data item pushbutton.

2 Point out the item to be decluttered. (Visual feedback as to which item was selected should occur.)

3 Move the item to the desired new location. The item must appear to move with the pointer. This helps the operator to position it in the least cluttered area of the screen. A line will appear between the item's offset location and its true location.

4 If the operator decides not to declutter the item after all, he should only have to press the ABORT pushbutton.

5 Press the COMPLETE pushbutton. The DECLUTTER pushbutton should remain activated until the operator turns it off.

(b) Rationale. Procedures must require a minimum amount of operator effort and training.

(41) Requirement and rationale number 41 (TEU).

(a) Requirement 41. The procedure for deleting a data item applies to all data types and should be similar to that listed below:

1 Press the DELETE data item pushbutton.

2 Point out the item or items to be deleted. More than one item can be deleted at a time. As each item is pointed to, it must disappear from the display.

3 If the operator decides not to delete the items selected, he should have the option of pressing the ABORT pushbutton, thereby restoring all the temporarily deleted symbols.

4 Press the COMPLETE pushbutton. The console should return to the operational state which existed prior to pressing DELETE.

(b) Rationale. Procedures must require a minimum amount of operator effort and training.

(42) Requirement and rationale number 42 (TEU).

(a) Requirement 42. The console must allow the user to create at least 10 branch duty symbols. Each created symbol must be associated with a particular pushbutton on the console. The pushbuttons are used in exactly the same manner as the permanent branch duty symbol pushbuttons in the creation and correction of military unit symbols. The procedure for creating additional branch duty symbols is listed below:

1 Press the CREATE SYMBOL pushbutton. This should cause an enlarged military unit flag (rectangle) to appear on the console screen.

2 By using the create graphic symbol procedure, (see requirement 37 above) create the desired branch symbol as a series of short line segments inside the flag.

3 Press the pushbutton the branch symbol is to be associated with. The pushbutton should allow the operator to affix a copy of the symbol to it. If a symbol has been previously assigned to this pushbutton, this step replaces it with the newly created branch duty symbol.

(b) Rationale. The ability to create branch duty symbols eliminates the need for having every possible FM 21-30 symbol in the permanent symbol generator. It also allows the operator to create symbols according to his own preference.

(43) Requirement and rationale number 43 (TEU).

(a) Requirement 43. The console must allow the user to create at least five individual graphic symbols. As is the case for branch duty symbols, each created graphic symbol must be associated with a particular pushbutton on the console. The pushbuttons are used in exactly the same manner as the permanent individual graphic symbol pushbuttons in the creation and correction of graphic symbols. The procedure for the creation of additional graphic symbols is the same as the procedure for military unit branch symbol creation (see requirement 42 above). When the operator presses the CREATE SYMBOL pushbutton, the enlarged rectangular format used in the creation of military unit branch duty symbols provides the operator with a ready frame of reference. Since the operator knows that the enlarged format reduces to the size of a military unit symbol rectangle on a display, he can create the desired graphic symbol to the appropriate size inside the format.

(b) Rationale. The ability to create graphic symbols eliminates the need for having every possible FM 21-30 symbol in the permanent symbol generator. It also allows the operator to create symbols according to his own preference.

(44) Requirement and rationale number 44 (TEU).

(a) Requirement 44. The console must allow for the creation of at least two line-type graphic symbols. The created symbol must be associated with a particular pushbutton on the console. The pushbuttons are used in exactly the same manner as the permanent line-type graphic symbol pushbuttons. The procedure for the creation of line-type graphic symbols is the same as that used for the creation of military unit symbols and individual graphic symbols (see requirements 42 and 43 above). By using the enlarged rectangular format as the frame of reference, the operator can create a repeatable element of the graphic line-type symbol of the appropriate size inside the format.

(b) Rationale. The ability to create line-type graphic symbols eliminates the need for having every possible FM 21-30 symbol in the permanent symbol generator. It also allows the operator to create symbols according to his own preference.

(45) Requirement and rationale number 45 (TEU).

(a) Requirement 45.

1 Ideally, background map display should require the operator to only specify the level of detail and the area of coverage desired. Registration with the dynamic symbology should be automatic. If a particular background is to be frequently displayed, the operator must have the option of giving it an identification label which will allow its recall without the operator having to respecify the level of detail and area of coverage. The currently selected categories of dynamic symbology in a newly selected area of coverage must appear automatically.

2 The procedure for obtaining a desired map background should be similar to that listed below:

a Press the SELECT MAP pushbutton.

b Use ASCII keys to type in the desired map identification label if the map is one that has been identified previously.

c If the desired map has not been identified, select the desired detail by pressing the appropriate pushbuttons (i.e., ROADS, GRIDS, RIVERS, TOWNS). Type in the coordinate (grid zone designation and four or six digits) for the extreme lower left and upper right corners of the desired area of coverage.

d Press the SELECT MAP pushbutton again. This causes the desired map to be displayed and the pushbutton to be turned off. (The map must be displayed in 15 seconds or less.)

3 The operator should be able to add or subtract map detail. This should only require that he press the appropriate map detail pushbutton (i.e., ROADS, RIVERS, GRIDS, TOWNS). Detail will either be added or subtracted depending on whether or not it is currently displayed.

4 If at any time the operator wants to give a label identification to the map currently displayed so that it can be recalled, he should be able to do so by pressing the ADD MAP ID pushbutton and then typing the desired label on the ASCII keyboard. Map identification labels should be console peculiar (i.e., each console will have its own set of labels). Other console operators will be able to retrieve a map identified on a different console by using the appropriate prefix for that console.

5 The label of the map currently displayed should appear at a particular location on the display screen. If that particular combination of detail and area of coverage has not been labeled, no label should appear. A list of labels currently being used to identify maps on that console should be available upon request of the operator. Maps may be deleted from this list by pressing the DELETE MAP ID pushbutton and pointing to the label of the map to be deleted.

(b) Rationale. This gives the operator the ability to tailor map backgrounds to meet his specific needs and have them available for immediate recall.

(46) Requirement and rationale number 46 (TEU).

(a) Requirement 46.

1 If the ideal background map display procedure described in requirement 45 is not possible, discrete background maps, although not as flexible, offer an alternate approach. If the user is given an infinite number of on-line discrete background maps, he can approach the flexibility of the ideal map described above. However, an infinite number of on-line maps that have varying areas of coverage and different combinations of detail is not realistic. Realizing this, the following considerations are provided to assist in the specification of systems that use discrete map background presentation.

2 Each display system must have a number of discrete maps on line. Each map in the set must be available within 15 seconds. Initial registration and cataloging of a map must only require that the operator point out two diagonally located grid intersections or two known (diagonally located) points and type in their coordinates (grid zone designator and 4, 6, or 8 digits). The operator must assign an identification

label to the map so that it can be easily recalled. This label must be visible whenever the map is displayed. Once the map is registered, it must not require reregistration upon recall.

3 Background orientation or scale must be immaterial when registering a map. There must be no requirement that the map be exactly vertical or centered or that it have a particular magnification factor. In addition, a means for easily changing on-line backgrounds either singly or as a set must be provided.

(b) Rationale. On-line map backgrounds of varying area of coverage and levels of detail are necessary to support the console operator in the performance of his duties. These backgrounds must be available for immediate recall and use.

(47) Requirement and rationale number 47 (TEU).

(a) Requirement 47.

1 The console must be able to store and display data items by category. When a new data item is added to the system's data base, the system must allow the user to specify which category or categories the data item is to be stored and displayed under. It must be possible to assign a data item to more than one category and to change the category or categories of any displayed data item. The number of categories required is approximately 30.

2 Data items associated with a particular echelon (e.g., hostile and friendly units) may be required to be displayed by echelon for a selected category. For example, a user may wish to display the category containing friendly unit locations but want to see only those units of brigade size or larger. A set of pushbuttons to specify the desired echelons should be provided for this purpose.

3 It is desirable to allow the user the option of specifying the time frame for categories which he selects. An example of the use of this option is the display of reported vehicular movement from (date time group) to (date time group). If the option is not exercised, the system displays all data for the selected category and echelon. The time frame applies to all categories selected for display.

4 The procedures listed below are provided as a guide to data category selection and category change. Initial assignment of a data item to a category is discussed in the procedure for data item creation (requirement 37 above) and the requirement for TOS message receipt (requirement 49 below).

a Category selection.

(1) Press the desired echelon pushbuttons for the categories to be displayed. The echelon selection applies to all displayed categories which have echelon associated data items.

(2) Press the desired category pushbuttons. This causes the display of data items in the desired categories for the specified echelon(s). Pressing a category pushbutton which is lit disengages the pushbutton, turns the light off, and causes all data items belonging to that category to be removed from the display.

b Category change.

(1) Press the CHANGE CATEGORY pushbutton. This causes all category pushbuttons which are lit to be turned off.

(2) Press the desired category pushbuttons.

(3) Point to the data item (or data items if more than one data item is to be stored in the new categories) on the display. (Visual feedback to indicate the selected symbols should occur.)

(4) Press the CHANGE CATEGORY pushbutton. This assigns the selected data items to the new categories. The light on this pushbutton turns off, and the previously lit category pushbuttons turn on.

(5) The user may press the ABORT pushbutton at any time during the procedure. This returns the display to the state it was in before the procedure was initiated.

(b) Rationale. The use of categories is analogous to the use of manual drops. The use of transparent overlays, or "drops", is commonplace in a TOC. Each drop depicts a specific data category or categories such as friendly unit locations and boundaries and is placed over a hard copy map. The drops can be viewed singly or in combination, one drop on top of the other. The easy assignment of a data item to a category or categories, along with rapid access to and display of data items in the desired category or categories, is essential to effective user management and analysis of data.

(48) Requirement and rationale number 48 (TEU).

(a) Requirement 48.

I A means for storing display scenes is required. The system must also have the capability to re-store these modified display scenes. The procedure for storing display scenes should be similar to that listed below:

- a Press the STORE HISTORY pushbutton.
 - b Type a brief description of the scene that was stored. Visual feedback of what is typed should appear on the lower edge of the scene.
 - c The system adds this scene description to its current listing of stored scenes for that particular console.
 - d Press the STORE HISTORY pushbutton again. This completes the storage procedure and the pushbutton light goes off.
- 2 The procedure for the recall of stored display scenes should be similar to that listed below:
- a Press the RECALL HISTORY pushbutton. A list of the currently stored scene descriptions for that console is displayed. (If the console operator wants a listing of another console's stored scenes, he types that console's prefix.)
 - b Point to the scene description desired. The selected scene must appear within 15 seconds. Deletion of scenes in the list should only require pressing the DELETE pushbutton and pointing to the appropriate description.
 - c Return to the display shown prior to history recall is accomplished by repushing the on-off RECALL HISTORY pushbutton.
- (b) Rationale. These stored scenes can be used for briefings on the large screen, unit historical data, and the development of different plans and analysis.

(49) Requirement and rationale number 49 (TEU).

(a) Requirement 49.

1 Each console must have the ability to send data items to, and receive data items from, TOS. Update of the TOS data base should only require that the operator press the TOS DATA pushbutton and point to the data item(s) selected. The data items, along with their associated free text, are sent to TOS when the TOS SEND pushbutton is pressed.

2 TOS data is either received as a result of a standing request for information (SRI) or a query from a particular console. The SRI or query establishes the console data category or categories that incoming data items are assigned to. When a data item is received, it is automatically displayed and highlighted if it is in the area of map coverage displayed. It is displayed and highlighted regardless of the currently selected categories. The item continues to be highlighted until the operator points to it and presses an ACCEPT, SAVE, or REJECT pushbutton to indicate that he sees the item. The ACCEPT pushbutton adds the data

item to the designated display categories. The SAVE pushbutton adds the item to a special TOS save category. Data items in the TOS save category can be transferred to display categories at any time. The REJECT pushbutton deletes the item. Blinking is an acceptable means for automatic highlighting although any other means that is equally as attention getting is acceptable. If a data item received from TOS is not in the currently displayed area of map coverage, it appears and is highlighted the first time the operator selects an area of coverage that includes the item's location. Military unit symbols that have branch duty symbols that are not contained in the permanent symbol generator must appear with the first four letters of the branch duty inside the rectangle.

3 When a TOS data item is an update to data already in the system, pressing the ACCEPT pushbutton causes automatic replacement of the previous information. An example is the automatic update of a particular unit's location or the relocation of a particular boundary.

(b) Rationale. This requirement recognizes the requirement for interoperability with a centralized data base such as TOS.

(50) Requirement and rationale number 50 (TEU).

(a) Requirement 50. The transfer of entire displays from one console to another must be provided for. This can be between consoles within an automated display system or between a console in one system and a console located in another system at another echelon. The transfer will generally be in answer to a verbal request for specific information. The procedure should only require that the operator obtain the desired display in the normal manner, press a SEND DISPLAY pushbutton, and type an identification for the console which is to receive the display.

(b) Rationale. The transfer of entire displays allows rapid exchange of information between various console users.

(51) Requirement and rationale number 51 (TEU).

(a) Requirement 51. Transmission of alphanumeric data from one display system to another display system's printer should be possible from the interactive graphic display console. The data is stored by category and is transmitted one category at a time. The procedure should only involve displaying the appropriate category, pressing a SEND ALPHANUMERIC pushbutton, and typing the prefix of the printer where output is desired.

(b) Rationale. This provides for maximum ease of alphanumeric data transmission.

(52) Requirement and rationale number 52 (TEU).

(a) Requirement 52.

1 An automated display system must have the ability to provide additional data on any display data item upon user request. It must also provide the user with the ability to add his own free text remarks.

2 To obtain additional data on a displayed data item or to add a comment on the item, a procedure similar to that listed below should be used:

a Press the EXTRA DATA pushbutton on the console.

b Point to the desired data item. This causes the display of a three-part format. The display of this format must not replace the graphic display. The format can be displayed on the same screen with the graphic display or on a separate, but nearby, alphanumeric display screen.

(1) The first part of the format is automatically completed by the system and includes, as a minimum, the grid coordinate(s) of the data item. Other data which can be included in this part of the format are the date time group, the originator, and the reliability of the data.

(2) The second part of the format is provided for the entry of optional free text remarks by the originator of the data item. If the data item is transmitted from an outside source such as TOS, the sender's remarks (if any) are entered here. If the data item is originated by the display system user, his remarks (if any) are entered here.

(3) The third part of the format is provided for optional free text remarks by the recipient of the data item. A data item transmitted from an outside source has this part of the format for the display system user's comments (if any).

c Type free text comments (if any) in the second part (originator) or third part (recipient) of the format.

d Press the EXTRA DATA pushbutton. This turns the pushbutton light off and deletes the extra data format from the display.

(b) Rationale.

1 Data items in tactical situation displays have associated data which normally is not displayed with the symbol that represents the item. This data is alphanumeric in nature. Examples of this type of data include the UTM grid coordinate(s) of the data item and free text remarks which elaborate on the data item.

2 Frequently, the viewer of a tactical situation display wants more specific information on a displayed data item. He may also wish to provide his own comments to further clarify the display of the item. A procedure currently used in TOC's is to code significant data items with a number or letter. The numbers or letters are listed with the appropriate clarifying data on the side of the display.

(53) Requirement and rationale number 53 (TEU).

(a) Requirement 53.

1 A number of control switches or knobs are required on the interactive graphic display console. The controls must be on the console. The console operator should not have to leave his position in order to reach them. The controls listed below must be included:

a Dynamic symbology brightness control knob. Turning the knob one way or the other increases or decreases the *overall* brightness of displayed dynamic symbology within the range from maximum brightness to the dynamic symbology being completely faded from the screen.

b Map background brightness control knob. Turning the knob one way or the other increases or decreases the *overall* brightness of the displayed map background. The brightness is controllable from maximum brightness to the map background being completely faded from the screen.

c Restart-reset pushbutton. This pushbutton is used when operator or system error causes the processor to halt. Pressing the pushbutton causes a reload of the display program if necessary and/or resetting of the program parameters to what they were before the halt. The system must be operational within 15 seconds after this pushbutton is pressed. However, return to full operational status within 2 or 3 seconds is highly desirable.

2 The controls listed below should be included on the console:

a Color brightness control knob(s). One knob is provided for each color of dynamic symbology. The knob has the same function and range as the dynamic symbology brightness control knob except that it controls the brightness of an individual color.

b Map feature brightness control knob(s). These controls are necessary if the ideal map background display is practical. One knob is required for each color used to identify a specific map feature (e.g., roads, vegetation, rivers). The function and range of the knob is the same as the map background brightness control knob except that it controls the brightness of an individual map feature color.

c Symbol size control knob. Turning the knob one way or the other varies (within a specified range) the size of all data items except line-type graphic items, circles, and ellipses. When the control is used, all parts of the data item (e.g., the rectangle, the branch duty symbol, the left identification, the right identification, and the echelon) are either enlarged or reduced proportionally. Changing the size of the symbol must not change the symbol's apparent map location.

3 Other controls may be required, depending upon the display technique used. For example, individual dynamic symbology and map background focus knobs may be necessary.

(b) Rationale. The size and brightness controls enhance display viewability. The restart-reset control allows the operator to quickly bring the processor back on line if it halts.

(54) Requirement and rationale number 54 (TEU).

(a) Requirement 54.

1 The display system must notify the interactive graphic display console operator when he performs a step in a procedure incorrectly. The notification means must be positively attention getting, must be rapid, and must specify exactly what was done wrong. An audio alert such as a bell or buzzer should sound whenever an error occurs. Incorrect attempts to recover from the error cause additional audio alerts. The error message display must not delete the current situation display. The error message continues to be displayed until the operator performs the correct step in the procedure or until he presses the ABORT pushbutton at which time the error message is deleted and the display returns to the state it was in before the series of commands was initiated.

2 The error message must tell the operator exactly what he did wrong. The use of error codes which require the operator to look up the code to determine the error is not user oriented and is not acceptable. Ideally, the error message should state what step of the procedure was performed incorrectly. For example, using the procedure outlined for the creation of military symbols, an error message might read: "Last pushbutton depressed was not branch duty."

(b) Rationale. The ease which the operating procedures are learned and used will be greatly enhanced by this feature. The audio alert is preferable to a visual alert because it precludes the possibility of the operator not detecting the error if he is looking away from where the visual alert is located.

(55) Requirement and rationale number 55 (RAM).

(a) Requirement 55. The principal users (i.e., G2, G3) should not be deprived access to a console for periods longer than 15 minutes.

(b) Rationale. The console is the primary device used to interact with the computer and its data base. If there are several consoles located within a TOC, the failure of one console, although detrimental to the console user, would not result in total system failure.

e. Group display output device. It is assumed that any display on the group display output device is first composed and displayed on an interactive graphic display console before being transferred to the group display.

(1) Requirement and rationale number 1 (VDD).

(a) Requirement 1. The group display output device must be able to display the 64-character ASCII set; the FM 21-30 symbols listed below; symbology added to the symbol generator by the user; circles; ellipses; and freehand graphics such as symbols for boundaries and axis of advance. The following symbols should be a part of the permanent symbol generator. FM 21-30 illustrates each symbol and provides examples of the use of the symbols.

Military Unit Symbols

HEADQUARTERS
CENTER OF MASS
TRAIN

NOTE: Military unit symbols must be displayed as actual or proposed. In addition, they must denote whether the represented unit is a task force.

Branch Duty Symbols

AIRBORNE	ARMOR	ENGINEER
AIR DEFENSE ARTILLERY	AVIATION	INFANTRY
AIRMOBILE	CAVALRY	MAINTENANCE
ANTITANK	CHEMICAL	PSYCHOLOGICAL OPERATIONS
FIELD ARTILLERY	ENGINEER, BRIDGE	SIGNAL
		TRANSPORTATION

Graphic Symbols

OBSERVATION POST	AMMUNITION SUPPLY POINT, ALL
COORDINATING POINT	TYPES (combat service support
MINE, ANTITANK	installation)
MINE, ANTIPERSONNEL	AID STATION (combat service
POL POINT, GROUND (combat service	support installation)
support installation)	

Line-Type Graphic Symbols

SOLID LINE	DASHED LINE
TRENCH, BASIC SYMBOL	TANK OBSTACLE, TYPE UNSPECIFIED
WIRE, CONCERTINA, SINGLE	LINE OF CONTACT (defensive frontline trace)

(b) Rationale. Tactical situation displays require this symbology as a minimum. The selection of the symbols for inclusion in the permanent symbol library is based on their expected frequency of use.

(2) Requirement and rationale number 2 (VDD).

(a) Requirement 2. The group display scene must appear to be an enlargement of the console display scene. The symbol style and proportion must match those used on the console.

(b) Rationale. This precludes identical display scenes on the console and on the group display from appearing different when, in fact, they are not.

(3) Requirement and rationale number 3 (VDD).

(a) Requirement 3. A minimum of three colors is required. Three colors allow friendly, enemy, and control measure symbols to be color coded. Four to six colors are desirable. Color selection must be based upon obtaining a high degree of contrast in relation to the map backgrounds the symbols will be displayed upon.

(b) Rationale. Distinction of friendly symbols from enemy symbols is possible on a one color display by means of shape coding. However, the enhanced ability of the user to readily distinguish between color coded enemy, friendly, and boundary data items at a glance is required to preclude delay in their discrimination. Additional colors over and above three allow the highlighting of selected symbols or the color coding of particular categories of information. The selected colors must stand out from the map background data. This enhances dynamic symbol legibility.

(4) Requirement and rationale number 4 (VDD).

(a) Requirement 4. The group display should be fully legible under normal office lighting (70 foot-candles at desk top level). This requirement could be relaxed to as low as 30 foot-candles. Full legibility is defined as easy identification by every viewer in an audience of 20 people of every symbol in a tactical situation display.

(b) Rationale. The group display's primary use is for briefings. Thirty foot-candles is the amount of light required for note taking.

(5) Requirement and rationale number 5 (VDD).

(a) Requirement 5. The symbol size should be variable. However, the device must be designed with one optimum symbol size in mind. The selected size should be independent of the size selected for the console. However, when a display is initially transferred to the group display, the operator should have the option of allowing it to appear in a size proportioned to the size selected on the console.

(b) Rationale. The capability to adjust display symbol size is desirable but not absolutely necessary. It allows the user to select the size symbol best suited for a particular display. One optimum symbol size is required to facilitate the design of the device.

(6) Requirement and rationale number 6 (VDD).

(a) Requirement 6. The display area must be large enough to display a tactical situation (maximum of 75 military unit symbols for a division) with a minimum amount of symbol clutter, but it must not be so large that it causes the audience undue eyestrain or head movement. The group display must be of sufficient size to comprehensibly present a tactical situation display to an audience of at least 20 people.

(b) Rationale. For a given distance from the display surface, there is a size limit on how much area an individual can see without undue eye or head movement. Audience eye and head movement are influenced by two factors: screen size and viewer's distance from the screen. User data indicates that the audience size for most division briefings does not exceed 20.

(7) Requirement and rationale number 7 (VDD).

(a) Requirement 7. The displayed symbology must not have any discernible flicker.

(b) Rationale. Flicker causes eyestrain.

(8) Requirement and rationale number 8 (VDD).

(a) Requirement 8. The brightness of each dynamic symbology color and of each map feature color should be under user control. The user must, as a minimum, be able to vary the overall brightness of the dynamic symbology and the overall brightness of the map background.

(b) Rationale. Individual color brightness control allows the user to subdue categories of information which at a particular moment are not of significant interest or which detract from other information. Overall brightness control allows adjustment to suit the ambient light environment.

(9) Requirement and rationale number 9 (PADC).

(a) Requirement 9. Data items superimposed against a map background on the group display output device must appear to be no more than 100 meters from the specified map location. This 100-meter limit applies for any method of data item location: keyboard coordinate entry, coordinates transmitted from an outside ADP source, points transmitted from the map overlay input device, or direct entry by pointing to the location on the console display. The limit applies regardless of the size of the area of coverage being viewed.

(b) Rationale. Current manual procedures for plotting symbols against the 1:50,000 scale standard military map have an inherent plotting accuracy. The average individual updating a map in the TOC will, with few exceptions, position a given symbol within 100 meters of its specified map location. Most display users in the operations and intelligence sections of the TOC are concerned with the effect that symbol placement accuracy has on the evaluation of the positional relationships of the displayed symbols. While some users may require greater accuracy, the inherent accuracy of manual map posting is acceptable to most users in the TOC.

(10) Requirement and rationale number 10 (PADC).

(a) Requirement 10. Data items are located either with single points (e.g., a military unit or a coordinating point) or with multiple points (e.g., a unit boundary or a trench line). Data items located with single points must be completely displayed if the point is inside the selected area of coverage. If any part of a multiple point data item is in the selected area of coverage, the part within the area of coverage must be displayed. The part to be displayed must include all points of the data item up to and including those at the intersection of the item with an edge (or edges) of the map background.

(b) Rationale. An incomplete display is unacceptable.

(11) Requirement and rationale number 11 (MB).

(a) Requirement 11. The group display output device should be capable of displaying map backgrounds for the three uses described below. As a minimum, the device must be capable of displaying map backgrounds for the first use.

1 Comprehension of the overall situation. For this purpose the user is not interested in being able to read all detail on the standard military topographic map, but he uses the map to provide general orientation for the superimposed symbology.

2 More detailed inspection of the terrain at or in the vicinity of a superimposed symbol or symbols. In this case the user is interested in a more exact relationship of the symbols to the terrain.

3 Terrain analysis without superimposed symbology. For example, when selecting the best terrain upon which to establish a defense or when planning a route of movement, the user wants to view the map background with no superimposed dynamic symbology.

(b) Rationale. Map backgrounds are used in the TOC for the three purposes described. A map background is an essential part of any tactical situation display. The display of the situation is relatively useless unless the symbology is superimposed upon a map background, thereby orienting the symbology to the terrain.

(12) Requirement and rationale number 12 (MB).

(a) Requirement 12. Map backgrounds based on the UTM grid system will normally be displayed on the group display. However, the group display should be able to accommodate other military grid systems. The UTM grid system requires that the device be able to display areas of coverage which include the junction of two or more map sheets and the junction of two or more 100,000-meter grid zones.

(b) Rationale. Maps having the UTM grid system are used in TOC's. Situation maps are frequently made up of two or more adjacent map sheets.

(13) Requirement and rationale number 13 (MR).

(a) Requirement 13. The group display must provide map background coverage for an area no less than 50 kilometers by 50 kilometers.

(b) Rationale. User data indicates that an area at least 50 kilometers by 50 kilometers is required for an overall situation display of an armored or mechanized division.

(14) Requirement and rationale number 14 (MB).

(a) Requirement 14. The backgrounds used for display of the *overall* tactical situation must be identical in area of coverage and level of detail to the backgrounds used on the console for the same purpose. This is the primary background type required for the group display.

(b) Rationale. The group display will be used primarily to show overall situation displays. The maps used for overall situation displays need to be identical to those used on the console, since the group situation display is created on a console before being transferred to the group display output device.

(15) Requirement and rationale number 15 (MB).

(a) Requirement 15. The map backgrounds which are used to present the *overall* division situation must be fully legible when viewed under the ambient light requirement for dynamic symbology legibility specified in requirement 4 above. Full legibility is defined as the ability of every individual in the audience to easily identify every item of map data on the displayed background.

(b) Rationale. Any data item which is not legible is of no informational value in describing the overall tactical situation.

(16) Requirement and rationale number 16 (MB).

(a) Requirement 16. In addition to the *overall* tactical situation display background requirement, if the display technique permits, the ability to display a map background with a degree of detail equal to the standard military 1:50,000 topographic map and with an area of coverage no less than 50 kilometers by 50 kilometers is desirable. The legibility of map detail on this background should be no less than that of the standard topographic map.

(b) Rationale. The availability of this background not only permits viewing of greater map detail but also allows the user to better associate the map display with the standard topographic map with which he is familiar. The viewer may have to move closer to the background to identify all detail.

(17) Requirement and rationale number 17 (MB).

(a) Requirement 17. The display of blowups which are identical to those used on the console is desirable.

(b) Rationale. These backgrounds can be used when one or more individuals in the audience desire more map detail. The interested individuals may have to move closer to the screen to identify all detail.

(18) Requirement and rationale number 18 (TEU).

(a) Requirement 18. All displays on the consoles should be displayable on the group display. As a minimum, displays of the *overall* tactical situation on the console must be displayable on the group display.

(b) Rationale. The primary use of the group display output device is to present displays to an audience of at least 20 people. The displays most frequently shown depict the situation for the division *overall* area of coverage.

(19) Requirement and rationale number 19 (TEU).

(a) Requirement 19. Display scenes on the group display output device must be displayed independent of display scenes on the console.

(b) Rationale. This permits a display to remain on the group display output device even though different displays are shown on the console. The console acts as the transfer device for the group display. Once the scene is transferred to the group display device, the console need not be tied up by displaying the same scene shown on the group display.

(20) Requirement and rationale number 20 (TEU).

(a) Requirement 20. Displays from the interactive graphic display console are transferred to the group display by pressing the GROUP DISPLAY pushbutton on the console. This action causes both the map background and the selected dynamic symbology to be displayed on the large screen. Once the transfer has been initiated, the display must appear on the large screen within 15 seconds. The capability to have the display appear within 5 seconds is highly desirable.

(b) Rationale. The procedure for transferring a display from the console should be easy and straight forward. Fifteen seconds is the maximum time that a user can be expected to wait without inconvenience for a scene to appear on the group display.

(21) Requirement and rationale number 21 (TEU).

(a) Requirement 21. If discrete map backgrounds are used, a means is required for their registration. Registration must require the operator to only point at and input the UTM coordinates of any two grid intersections diagonally located in relation to each other. The background must not have to be exactly horizontal, vertical, or centered. Once registered, the background must be available for display without re-registration each time it is retrieved.

(b) Rationale. This provides the user maximum ease of use when registering a discrete map background.

(22) Requirement and rationale number 22 (TEU).

(a) Requirement 22.

1 A number of control switches or knobs are required on the group display output device. The controls must be located near the face of the screen, for easy access to a briefer or to an individual performing viewability adjustments to suit the audience.

2 The controls listed below are required. Other controls may be required depending upon the display technique used. For example, individual dynamic symbology and map background focus knobs may be necessary.

a Dynamic symbology brightness control knob. Turning the knob one way or the other increases or decreases the *overall* brightness of displayed dynamic symbology within the range from maximum brightness to the dynamic symbology being completely faded from the screen.

b Map background brightness control knob. Turning the knob one way or the other increases or decreases the *overall* brightness of the displayed map background. The brightness is controllable from maximum brightness to the map background being completely faded from the screen.

3 The following controls are desirable:

a Color brightness control knob(s). One knob is provided for each color of dynamic symbology. The knob has the same function and range as the dynamic symbology brightness control knob except that it controls the brightness of an individual color.

b Map feature brightness control knob(s). These controls are necessary if the ideal map background display is practical. One knob is required for each color used to identify a specific map feature (e.g., roads, vegetation, rivers). The function and range of the knob is the same as the map background brightness control knob except that it controls the brightness of an individual map feature color.

c Symbol size control knob. Turning the knob one way or the other varies (within a specified range) the size of all data items except line-type graphic items, circles, and ellipses. When the control is used, all parts of the data item (e.g., the rectangle, the branch duty symbol, the left identification, the right identification, and the echelon) are either enlarged or reduced proportionately. Changing the size of the symbol must not change the symbol's apparent map location.

(b) Rationale. These controls enhance the viewability of displays on the group display output device.

(23) Requirement and rationale number 23 (RAM).

(a) Requirement 23. Failures while briefing the commander should happen infrequently. Downtimes longer than 5 minutes have no real limit, although they should be reasonable (i.e., not more than several hours).

(b) Rationale. This downtime requirement stems from the reality that the commander, after waiting 5 minutes, will most likely continue the briefing from a console rather than wait for the group display to return to operation. When the group display is not actually being used for a briefing but is being used to display a situation of interest to a number of people in the TOC (e.g., the current enemy and friendly situation), the temporary failure of the group display can be tolerated because the situation shown on the group display can be seen on a console.

f. Map overlay input device.

(1) Requirement and rationale number 1 (PADC).

(a) Requirement 1. The map background used on the map overlay input device must be registered in such a manner that a data item entered as a series of points from either the overlay or the map will, if displayed on the console or group display, have the points displayed no more than 100 meters from the points entered through the device.

(b) Rationale. This is in accord with the 100-meter placement accuracy requirement of the console and the group display.

NOTE: The map overlay input device can serve two purposes in a TOC: the input to the system of freehand graphic data such as that found on an operation overlay (e.g., symbols for boundaries, objectives, phase lines); input to the system of actual map data (e.g., outlining a hill mass) to allow the user to highlight or modify map backgrounds. Either use of the device requires that the overlay or the actual map sheet be placed on the device and the data to be input then be traced or input to the system in some manner.

(2) Requirement and rationale number 2 (MB).

(a) Requirement 2. The device must be large enough to accommodate the map area of coverage for the majority of division tactical situations (i.e., no less than 50 kilometers by 50 kilometers). The size of a 50-kilometer by 50-kilometer area on a scale of 1:50,000 (the scale of maps most widely used in the division) is 1 meter by 1 meter.

(b) Rationale. The area of coverage required for most division tactical displays is at least 50 kilometers by 50 kilometers.

(3) Requirement and rationale number 3 (MB).

(a) Requirement 3. The registration of a map on the device must only require an operator to point at and input the UTM coordinates of any two grid intersections diagonally located in relation to each other. The map must not have to be exactly horizontal, vertical, or centered.

(b) Rationale. Entry of map data or overlay data requires that the map or overlay first be registered. The registration procedure should provide for maximum ease of use.

(4) Requirement and rationale number 4 (MB).

(a) Requirement 4. The device must be able to accept for registration maps which use the UTM grid system. Map areas to be registered may include the junction of two or more map sheets and the junction of two or more 100,000-meter grid zones.

(b) Rationale. Maps in a division TOC use the UTM grid system.

(5) Requirement and rationale number 5 (MB).

(a) Requirement 5. The device should accept maps of any scale but must, as a minimum, accept maps with a scale of 1:25,000, 1:50,000, 1:100,000, and 1:250,000.

(b) Rationale. The scales listed are those used in a division TOC.

(6) Requirement and rationale number 6 (TEU).

(a) Requirement 6.

1. The procedure for entry of freehand graphic data should be similar to the procedure listed below:

a. On the console, select the desired area of coverage for monitoring the input. (This should not have to be the exact area registered on the input device.)

b. Press the OVERLAY DEVICE pushbutton on the console. This activates the map overlay input device.

c. Press the desired graphic data line segment, the desired data category, and the desired color pushbuttons on the console. All points input from the overlay device are displayed and connected by the selected

graphic line segment in the selected color. The desired type of line segment, the data category, and the color can be changed at any time by pressing the appropriate line-type, category, and color pushbuttons.

d If the map on the input device is not registered, type in the grid coordinates of two diagonally located grid intersections and point to these points on the map. This step should not have to be performed again unless the map is moved or a new map is positioned on the device.

e Press the CREATE ITEM pushbutton on the input device.

f Input the desired data item by pointing to the series of points defining the data item on the overlay. As each succeeding point is selected, the resulting cumulative line segment should appear on the console. If the operator is not satisfied with the last few line segments, he should be able to delete them by pressing the BACKTRACK pushbutton. If the operator is not satisfied with the entire item, he should have the option of starting again by pressing the CREATE ITEM pushbutton again.

g Press the COMPLETE pushbutton.

h Input additional items by repeating e, f, and g above.

i. After all entries have been made, the device is turned off by deactivating the OVERLAY DEVICE pushbutton on the console.

2 The procedure outlined above can also be used for the input of freehand graphic data directly from a map. As far as the device is concerned, it is immaterial whether the data input is from an overlay or directly from the map as long as the user specifies the category under which each data item is to be displayed.

(b) Rationale. The procedure for using the map overlay input device should provide maximum ease of use for the input of freehand graphic data.

(7) Requirement and rationale number 7 (TEU).

(a) Requirement 7. A distance measurement capability is desirable. The measured distances must be within 5 percent of the actual distance. The procedure should be similar to the procedure listed below:

1 Press the OVERLAY DEVICE pushbutton on the console.

2 If the map on the input device is not registered, type in the coordinates of two diagonally located grid intersections and point to these points.

3 Press the DISTANCE MEASUREMENT pushbutton.

4 Measure the desired cumulative distance on the map by pointing to the start point, succeeding points of inflection, and the end point.

5 Press the COMPLETE pushbutton. This causes the distance measured to appear in meters on the console screen.

6 Measure additional distances by repeating 4 and 5 above.

7 Turn off the device by deactivating the OVERLAY DEVICE pushbutton.

(b) Rationale. Distance measurement is commonplace in TOC planning and operations (e.g., road movement planning). This device is a "natural" for distance measurement, since very little effort is required to provide this capability.

(8) Requirement and rationale number 8 (RAM).

(a) Requirement 8. Maintainability of the device should be such that any unscheduled maintenance action does not exceed 30 minutes.

(b) Rationale. Use of the map overlay input device is not expected to be continuous; but when the device is required, its availability and reliability must be high. Thirty minutes is the maximum time that a user can be reasonably expected to wait if he has map or overlay data which he needs to input to the system.

g. Map overlay output device. The map overlay output device is used to output hard copy of interactive graphic display console scenes. The output is in the form of an overlay.

(1) Requirement and rationale number 1 (VDD).

(a) Requirement 1. The map overlay output device must be able to display the 64-character ASCII set; the FM 21-30 symbols listed below; symbology added to the symbol generator by the user; circles; ellipses; and freehand graphics such as symbols for boundaries and axis of advance. The following symbols should be a part of the permanent symbol generator. FM 21-30 illustrates each symbol and provides examples of the use of the symbols.

Military Unit Symbols

HEADQUARTERS
CENTER OF MASS
TRAIN

NOTE: Military unit symbols must be displayed as actual or proposed. In addition, they must denote whether the represented unit is a task force.

Branch Duty Symbols

AIRBORNE	ARMOR	ENGINEER
AIR DEFENSE ARTILLERY	AVIATION	INFANTRY
AIRMOBILE	CAVALRY	MAINTENANCE
ANTITANK	CHEMICAL	PSYCHOLOGICAL OPERATIONS
FIELD ARTILLERY	ENGINEER, BRIDGE	SIGNAL
		TRANSPORTATION

Graphic Symbols

OBSERVATION POST	AMMUNITION SUPPLY POINT, ALL TYPES (combat service support installation)
COORDINATING POINT	
MINE, ANTITANK	
MINE, ANTI PERSONNEL	
POL POINT, GROUND (combat service support installation)	AID STATION (combat service support installation)

Line-Type Graphic Symbols

SOLID LINE	DASHED LINE
TRENCH, BASIC SYMBOL	
WIRE, CONCERTINA, SINGLE	TANK OBSTACLE, TYPE UNSPECIFIED LINE OF CONTACT (defensive frontline trace)

(b) Rationale. Tactical situation displays require this symbology as a minimum. The selection of the symbols for inclusion in the permanent symbol library is based on their expected frequency of use.

(2) Requirement and rationale number 2 (VDD).

(a) Requirement 2. The symbol style and proportion of output must match that used on the interactive graphic display console.

(b) Rationale. This precludes output which appears different from the console display when, in fact, it is not.

(3) Requirement and rationale number 3 (VDD).

(a) Requirement 3. A minimum of three colors is desired. Three colors allow friendly, enemy, and control measure symbols to be color coded. Four to six colors are desirable. Color selection must be based upon obtaining a high degree of contrast in relation to the map backgrounds the overlays will be displayed against.

(b) Rationale. Distinction of friendly symbols from enemy symbols is possible on a one color display by means of shape coding. However, the enhanced ability of the user to readily distinguish between color coded enemy, friendly, and boundary data items at a glance is required to preclude delay in their discrimination. Additional colors over and above three allow the highlighting of selected symbols or the color coding of particular categories of information. The selected colors must stand out from the map background data. This enhances dynamic symbol legibility.

(4) Requirement and rationale number 4 (VDD).

(a) Requirement 4. The overlay must be capable of being output on transparent material. This is not intended to exclude output on other material such as paper.

(b) Rationale. This allows placement of the resulting overlay over a standard military topographic paper map where it will normally be used. The contrast of the symbols against the standard military topographic paper map is an important consideration.

(5) Requirement and rationale number 5 (VDD).

(a) Requirement 5. The symbology when shown against a standard military topographic paper map must be fully legible in as little as 30 foot-candles of ambient light.

(b) Rationale. Low ambient light levels may exist where the overlays will be used.

(6) Requirement and rationale number 6 (VDD).

(a) Requirement 6. One symbol size is all that is required. The size should be selected so that the symbols are fully legible to the individuals working with a map board under 30 foot-candles of light. However, the symbols must be small enough to present a tactical situation display that is not unduly cluttered.

(b) Rationale. Overlays must be fully legible and present tactical situation displays that are not unduly cluttered.

(7) Requirement and rationale number 7 (PAC).

(a) Requirement 7. The overlays produced by the map overlay output device will be used with standard military paper maps. The data items on the overlay, when placed over the maps, must be no more than 100 meters from the symbol locations used in inputting the overlay to the display system.

(b) Rationale. Current manual procedures for plotting symbols against the 1:50,000 scale standard military map have an inherent plotting accuracy. The average individual updating a map in the TOC will, with few exceptions, position a given symbol within 100 meters of its specified map location. Most display users in the operations and intelligence sections of the TOC are concerned with the effect that symbol placement accuracy has on the evaluation of the positional relationships of the displayed symbols. While some users may require greater accuracy, the inherent accuracy of manual map posting is acceptable to most users in the TOC.

(8) Requirement and rationale number 8 (PAC).

(a) Requirement 8. Every data item on a display scene selected for output as an overlay must be present on the hard copy produced by the device.

(b) Rationale. Overlays produced by the device must be complete. Missing data items on an overlay degrade the utility of the overlay.

(9) Requirement and rationale number 9 (MB).

(a) Requirement 9. The map overlay output device copy size must be at least 1 meter by 1 meter.

(b) Rationale. This allows the complete output of most division tactical situation displays for the most commonly used scale and required area of coverage. A 50-kilometer by 50-kilometer area of coverage on a 1:50,000 scale standard military map measures 1 meter by 1 meter.

(10) Requirement and rationale number 10 (MB).

(a) Requirement 10. The device should have the ability to provide copy to any scale desired. As a minimum, the operator must be able to specify scales of 1:25,000, 1:50,000, 1:100,000, and 1:250,000.

(b) Rationale. Division tactical overlays will normally be used with standard scale military maps and therefore must have a 1 to 1 ratio with these maps.

(11) Requirement and rationale number 11 (TEU).

(a) Requirement 11. All tactical display scenes on the interactive graphic display console should be reproducible in multiple copy on the map overlay output device.

(b) Rationale. Overlays are a normal annex to operation orders.

(12) Requirement and rationale number 12 (TEU).

(a) Requirement 12. The procedure for producing hard copy on this device is similar to the procedure used for outputting a scene to the group display device. The scene must first be displayed on an interactive graphic display console. The PRODUCE OVERLAY pushbutton on the console is then pressed. After typing the desired number of copies, the console should be free to return to other display functions.

(b) Rationale. Maximum ease in producing overlays of a selected display scene should be provided.

(13) Requirement and rationale number 13 (TEU).

(a) Requirement 13. The time to produce one copy must not exceed 5 minutes. However, a time of 1 to 2 minutes per copy is extremely desirable.

(b) Rationale. The device should easily improve upon the time required to manually produce an overlay. One to two minutes per copy facilitates production of multiple copies.

(14) Requirement and rationale number 14 (TEU).

(a) Requirement 14. The map overlay output device should be capable of remote operation.

(b) Rationale. This allows the transmission of overlays to lower echelons which may not have an automated display system. This device may require a small memory unit or buffer to preclude tying up communication lines.

(15) Requirement and rationale number 15 (RAM).

(a) Requirement 15. Maintainability of the device should be such that any unscheduled maintenance action does not exceed 30 minutes.

(b) Rationale. Use of the map overlay output device is not expected to be continuous; but when the device is required, its availability and reliability must be high. Thirty minutes is the maximum time that a user can be reasonably expected to wait if he has map or overlay data which he needs to output from the system.

h. Printer.

(1) Requirement and rationale number 1 (VDD).

(a) Requirement 1. The characters in the 64-character ASCII set are required for output by the printer. The size, style, and proportion of the characters must be fully legible to the user when they are viewed as lines of print in as little as 30 foot-candles of ambient light.

(b) Rationale. Thirty foot-candles is the minimum ambient light required for reading high contrast or well-printed material.

(2) Requirement and rationale number 2 (TEU).

(a) Requirement 2. The print area must be visible to the user.

(b) Rationale. This precludes the possibility of output not being noticed by the user or his having to advance the page to read newly received data.

(3) Requirement and rationale number 3 (TEU).

(a) Requirement 3. The size of printer output copy should be the standard 8 inches by 10 1/2 inches.

(b) Rationale.

1 Examples of hard copy which could be output by the printer include:

OPORD	TASK ORGANIZATION	TABULAR (CHART) DATA
INTSUM	CHALLENGE/PASSWORD	FREE TEXT MESSAGES
SITREP	WEATHER DATA	FORMATTED MESSAGES

2 None of the above require hard copy size larger than the 8 inch by 10 1/2 inch size used in the manual system. The printer should provide hard copy in the size normally used in the manual system. This will allow the hard copy to be reproduced on available reproducing equipment (e.g., xerox, thermofax). Reproduction by existing equipment negates the requirement for multiple copies.

(4) Requirement and rationale number 4 (TEU).

(a) Requirement 4. Receipt of data from an outside ADP source must be automatic. When the printer is activated, an audible alert (adjustable by the operator down to zero volume) must indicate to the operator that output is being printed.

(b) Rationale. Receipt of ADP data from an outside source should not require operator interaction. Incoming data may go unnoticed if there is no alert.

(5) Requirement and rationale number 5 (TEU).

(a) Requirement 5. Output of alphanumeric data from the system's data base should only require the display of the desired categories and pressing of the PRINTER pushbutton. The pushbutton should remain lit until the output is produced; then it should automatically turn off.

(b) Rationale. This provides maximum ease of use when producing printer output of selected categories.

NOTE: The procedure for initiating printer copy from the interactive graphic display console is not intended to restrict initiation of printer copy to the interactive graphic display console alone. Certain types of alphanumeric data may be better displayed on the alphanumeric display console and then output to the printer by means of a pushbutton on the alphanumeric display console.

(6) Requirement and rationale number 6 (TEU).

(a) Requirement 6. The printer must be capable of outputting a full page of single-spaced alphanumerics within 30 seconds.

(b) Rationale. Thirty seconds is well within the capability of available medium speed printers.

(7) Requirement and rationale number 7 (RAM).

(a) Requirement 7. Maintainability should be such that any unscheduled maintenance action does not exceed 30 minutes.

(b) Rationale. The printer is normally on continuously, even though it provides output at unspecified intervals. Two primary uses of the printer are the "logging" of messages from ADP sources outside the automated display system and the output of alphanumeric data contained in the system's data base. Therefore, the operational availability and the reliability of the printer must be high.

i. Alphanumeric display console.

(1) Requirement and rationale number 1 (VDD).

(a) Requirement 1. The symbols required to be displayed on the console are the 64-character ASCII set. Message formats and tabular chart outlines, either completed or to be completed, will also be displayed.

- (b) Rationale. Alphanumeric displays consist of ASCII characters displayed against message formats or tabular chart outlines.
- (2) Requirement and rationale number 2 (VDD).
- (a) Requirement 2. Two colors are desirable.
- (b) Rationale. The second color allows message formats and tabular chart outlines to be readily distinguished from the dynamic data.
- (3) Requirement and rationale number 3 (VDD).
- (a) Requirement . The screen size should be designed to display approximately 1,500 characters to an operator who is within easy arm's reach of the display.
- (b) Rationale. This is the number of characters specified for the M10D in the TOS MN document. Screen size is affected by the distance of the operator from the screen, character size, and the number of characters to be displayed.
- (4) Requirement and rationale number 4 (VDD).
- (a) Requirement 4. Displays on the console must be fully legible under normal office lighting (70 foot-candles at desk top level).
- (b) Rationale. This precludes eyestrain and fatigue of the individuals working in the immediate area. Full legibility under normal office lighting is well within the capability of available alphanumeric display consoles.
- (5) Requirement and rationale number 5 (VDD).
- (a) Requirement 5. The operator must be able to adjust the brightness of the display by means of a brightness control located on the console.
- (b) Rationale. This allows the operator to adjust the brightness of the display to suit the ambient light environment.
- (6) Requirement and rationale number 6 (TEU).
- (a) Requirement 6. Certain design features should be incorporated to facilitate operator use of the device. Examples of these design features are listed below:
- I Instantaneous visual feedback when a character is being typed or a manipulation is being performed so the operator can immediately see the result of his action.

2 A brightness control with which the operator can adjust the display brightness to the ambient light environment.

3 A standard (typewriter) keyboard layout for convenient entry of ASCII characters.

4 A control to shift left, right, up or down.

5 Margin and tab controls to assist in formatting data as well as completing blank formats.

6 A marker symbol to assist in positioning data by indicating where the next character will appear.

(b) Rationale. These design features will facilitate operator use of the console.

(7) Requirement and rationale number 7 (TEU).

(a) Requirement 7. The procedures implemented to accomplish the functions of the alphanumeric display console must provide for maximum ease of use. The procedures recommended for the interactive graphic display console should be referred to for the degree of simplicity and user convenience that is desired. Examples of the functions the device should be able to perform are listed below:

1 Display of message formats which are used for data input into the system, data input to TOS, or query of the TOS data base.

2 Display of alphanumeric data, to include tabular data, contained in the system's data base.

3 Manipulation and update of displayed alphanumeric data.

4 Composition and display of free text data.

5 Transmission of formatted data to TOS.

6 Transmission of formatted and free text data to another display system's alphanumeric display console, interactive graphic display console, or line printer.

7 Transmission of displayed alphanumeric data to an interactive graphic display console of the display system.

8 Output of displayed alphanumeric data on the system's line printer.

(b) Rationale. The alphanumeric display console is the primary device used for the input, display, manipulation, and transmission of alphanumeric data.

(8) Requirement and rationale number 8 (RAM).

(a) Requirement 8. The reliability and maintainability of the alphanumeric display console should be such that the principal users (i.e., G2, G3) of the system are not deprived access to a console for more than 15 minutes.

(b) Rationale. If there are several alphanumeric display consoles located within a TOC, the failure of any one console, although detrimental to the console user, does not result in total system failure.

Section III - Performance of Evaluated Automated Display Systems

2-7. Introduction.

a. General.

(1) This section addresses objective 3 of FMI16 - Evaluate the suitability of candidate computer driven display technological approaches to meet proposed requirements criteria.

(2) The section evaluates the performance of the three candidate automated display systems (scribe, CRT, photochromic) against the requirements stated in section II, paragraph 2-6 of this chapter. Each requirement is addressed in the order that it is stated in paragraph 2-6.

(3) A detailed description of the specific device of each of the three systems precedes evaluation of the devices. Each requirement is addressed in the format listed below:

(a) Statement of the requirement.

(b) Performance of each device. The performance of each device is rated as "No," "Met," or "Exceeded," depending upon whether the performance was judged as falling short of, meeting, or exceeding the requirement. Some requirements identify a capability which was not required by the design specifications for the device. For these requirements, the rating is stated as NA (not applicable).

(c) Discussion of experimentation data (objective and subjective) which determined the performance ratings.

(d) Significant performance data (when appropriate).

(4) A comparative analysis of the relative performance of each candidate system device in meeting the stated requirements concludes the section.

b. Map backgrounds.

(1) As a result of the map conference held at Fort Hood in July 1972 (chapter 1, section II, subparagraph I-4f), the Defense Mapping Agency (DMA) prepared map background slides to be used during the experimentation. The CRT system was the only system which was able to display the full complement of maps prepared by DMA. These slides were on standard 35-millimeter slide film and were incompatible with the projection technique used by the scribe system. The process for etching quality, color map data on the glass slides used in the scribe reference projectors was difficult and costly. It was decided, therefore, not to obtain color slides for the scribe system. Instead, the Northrop Corporation provided a set of two white-on-black background slides for the group display. The area of coverage for both slides was 40 kilometers by 40 kilometers. One slide contained the amount of detail on the level 6 map background described in figure 2-3. The other was a photograph of a 1:50,000 scale standard military topographic map.

(2) In order to obtain comparison data for legibility of the scribe dynamic symbology against color map backgrounds, a Model 800 Kodak Carousel projector with a lens having the same focal length and speed as that used on the CRT group display was used. The projector was mounted behind the group display at the height and standoff distance necessary to project a 5-foot by 5-foot map image onto the group display screen. The slides used with this projector were a duplicate set of those used with the CRT group display background projector. The projector and map backgrounds were also used during the CPX. The level 4, level 6, and standard military topographic map backgrounds (fig 2-3) were used during legibility testing of dynamic symbology on the scribe group display.

(3) The consoles in the scribe system did not have a map background display capability. The operator was assisted in visualizing the area of coverage and in approximating the location of displayed symbols by computer-generated tick marks.

(4) The map backgrounds prepared by DMA for use with the CRT system are described in figure 2-3. Each background was on a 35-millimeter color slide. The image area on the analysis console slides was 18 millimeters by 18 millimeters, and the area on the group display slides was 22 millimeters by 22 millimeters. The required map area of coverage for the CPX was provided by a number of overlapping slides for each type background. The amount of overlap between adjacent slides was 50 percent.

Type of background	Area of coverage (kilometers)	Description
Level 6	32 by 32	All data was highlighted against a black background. Data included hilltops; major rivers, lakes, roads, and towns; and grid lines 10 kilometers apart.
Level 5	32 by 32	All data was highlighted against a black background. Data included all that found on the level 6 map plus bodies of water more than 60 feet wide, railroads, all towns, and grid lines 5 kilometers apart.
Level 4	32 by 32	All data was highlighted against a black background. Data included all that found on the level 5 map plus slopes greater than 60 percent, secondary roads, and major vegetated areas.
Level 3	32 by 32	All data was highlighted against a black background. Data included all that found on the level 4 map plus contour lines at 200 meter intervals, unpaved roads, streams and creeks less than 60 feet wide, unpaved roads, vegetated areas more than one grid square, power lines, and grid lines 1 kilometer apart.
Standard military topographic map (minus)	32 by 32	Photograph (slide) of a 1:50,000 scale standard military topographic map with the following omitted: all contour lines except those at 100-meter intervals, intermittent streams, foot trails, orchards, vineyards, and isolated buildings.
Standard military topographic map	32 by 32	Photograph (slide) of 1:50,000 scale standard military topographic map area.

Figure 2-3. Map backgrounds.

Type of background	Area of coverage (kilometers)	Description
Orthopictomap	16 by 16	Photograph (slide) of 1:25,000 scale orthopictomap area.
Joint planning map	160 by 160	Photograph (slide) of a 1:250,000 scale standard military map area.

Figure 2-3 (cont). Map backgrounds.

(5) The map backgrounds available with the photochromic system were specified by USAMC-ECOM. The backgrounds for the group display were 70-millimeter color slides of 1:50,000 scale standard military topographic map areas. A matching set of 35-millimeter slides was used on the data entry and edit module (DEEM). The map area of coverage was 36 kilometers in the east-west direction and 27 kilometers in the north-south direction. The image area on the console slides measured 24 millimeters by 18 millimeters. The image area on the group display slides measured 76 millimeters by 57 millimeters. Area of coverage continuity was provided by a 33 percent overlap between adjacent slides.

(6) For the purpose of obtaining dynamic symbology legibility comparison data on the photochromic system, DMA prepared a set of level 4 and level 6 map backgrounds on 70-millimeter slides. These backgrounds were identical to those used on the CRT system, except that the map data was on a white rather than a black background. This made them compatible with the projection technique employed by the photochromic group display device. The level 4 and level 6 35-millimeter background slides which were used on the CRT group display were also used for dynamic symbology legibility testing on the DEEM.

c. Reliability, availability, and maintainability. The experimentation was not designed to collect reliability, availability, and maintainability data. It was focused on the collection of specific performance data. Additionally, the scribe and CRT systems used commercial hardware. Consequently, the equipment was not required to operate continuously, nor to operate in a field environment in the performance of display functions associated with TOC mission accomplishment. Each system was operated for less than 250 hours in increments of 8 hours or less. Therefore, three systems were not evaluated as to their ability to meet reliability, availability, and maintainability requirements. However, a list of the corrective maintenance actions which occurred during the experimentation was maintained for each system. This list is contained in part three, section IV.

2-8. Display Processor. The requirements for the display processor were all identified as a result of the experimentation. Therefore, they are not addressed in this section. A description of the display processor used by each system follows. All three systems employed an integral general purpose digital minicomputer to process data and control the operation of the system. Each minicomputer was programmed in the assembly language peculiar to that computer. Limited onsite modification of the minicomputers' operating systems was possible by vendor programmer input of individual modification instructions through manual manipulation of binary switches to represent the computer words. The integral display processors gave each system a "stand-alone" operational capability.

a. *Scribe - display processor.* The display processor was a Northrop NDC-1060 minicomputer which contained 16,000 28-bit words of core memory. Approximately 12,000 words were used for the operating system and display routines. The remainder of core memory was used for storage of the user's data base.

b. *CRT - display processor.* The CRT system used a Honeywell Model 316 as the display processor. The processor had 16,000 16-bit words of core memory. Approximately 12,000 words were used for the operating system and a table which represented the data items in the user's data base. The remaining part of core memory was used for the storage of the display routine currently in use. These routines were stored in a magnetic disk storage unit which contained approximately 1.25 million 16-bit words. The routines were brought into core memory as required. The actual description of each data base item was also stored on the magnetic disk and brought into core when manipulation of the item was required.

c. *Photochromic - display processor.* The display processor was a ROLM Model 1601 Ruggednova which contained 32,000 16-bit words of core memory. Memory was allocated for the operating system, the display list describing the data items for the photochromic film display, and the display list describing the data items for the DEEM.

2-9. Interactive Graphic Display Console (Individual Display).

a. *General.* A description of each device in the three candidate systems which performed functions corresponding to the requirements stated for the interactive graphic display console follows. The display screen for all of the devices was within easy arm's reach of an operator seated at the controls.

(1) *Scribe - editing console (EC).*

(a) The editing console was a Tektronix 611 CRT storage tube. A medium persistence phosphor on the rectangular display screen provided green symbology. The console was initially programed to refresh the display periodically (every 8 minutes), but the refresh overrode and

interfered with operator manipulation of the display. The refresh of the display was reprogrammed to be solely under operator control.

(b) The display screen measured 8 1/4 inches horizontally and 6 3/8 inches vertically. Symbols were generated by using a stroking technique. Alphanumeric, graphic, and military unit symbols were displayed in a single color.

(c) The interactive controls provided with the console were a keyboard and a joystick. The use of these controls and the console performance for the applicable requirements are discussed in b below.

(d) The console was not capable of displaying map backgrounds. Tick marks displayed on the left and bottom edges of the screen assisted the operator in approximating the locations of displayed symbols. The distance between the tick marks was determined by the map area of coverage selected. The entire surface of the rectangular screen was used for the selected map area of coverage. The map areas used in FMI16 were square. Thus, the actual screen dimension of a specific map distance (e.g., 1,000 meters) in the horizontal direction was greater than the actual dimension in the vertical direction.

(2) Scribe - analyst console (AC).

(a) The analyst console used a magnetically deflected, 21-inch diagonal Thomas CRT storage tube. A medium persistence phosphor on the rectangular screen provided white symbology against the gray filter glass surface. It was initially programmed (as was the editing console) to refresh the display periodically. The automatic refresh was disabled and refresh was placed under operator control.

(b) Symbols were generated by a raster scan technique (1,029 lines). The console was capable of displaying alphanumeric, graphic, and military unit symbology in the single color. The symbols that the analyst console were capable of displaying were identical to those of the editing console.

(c) The interactive controls provided with the console were a keyboard, a trackball, and a light pen. The use of these controls and the console performance for the applicable requirements are discussed in b below.

(d) The console was not capable of displaying map backgrounds. The use of tick marks as described for the editing console assisted the operator in approximating the locations of displayed symbols. The entire surface of the rectangular screen was used for the map area of coverage. The map areas used in FMI16 were square. Thus, the actual screen dimension of a specific map distance (e.g., 1,000 meters) in the horizontal direction was greater than the actual dimension in the vertical direction.

(3) CRT - analysis console (AC).

(a) The analysis console used a magnetically deflected, multicolor display with a single-gun beam penetration type CRT. Color selection was determined by the CRT anode voltage which in turn controlled the degree to which electrons penetrated phosphor layers on the tube screen. The phosphor layers provided a four color capability: red, orange, yellow, and green; but the system design allowed for only two voltage inputs. This resulted in a two color display. The colors used during the experimentation were orange and green. Symbols displayed on the console were refreshed by a refresh buffer unit (RBU) separate from the console. (The RBU also refreshed symbols displayed on the group display.) A stroking technique with a maximum refresh rate of 60 hertz was used to generate and maintain display of symbology.

(b) The CRT had a 19-inch diameter screen. The map image area on the screen was 11 1/4 inches square. The areas between the screen perimeter and the left border, right border, and lower border of the map area were used to display menus for operator interaction with the system.

(c) The console displayed alphanumeric, graphic, and military unit symbology in the two colors.

(d) The interactive controls provided with the console were a keyboard, a light pen, a trackball, and 16 coded function switches. The use of these controls and the console performance for the applicable requirements are discussed in b below.

(e) Map backgrounds were displayed on the face of the rear-ported CRT by a Kodak Ektographic RA-960 slide projector. Map backgrounds from the 80 positions available in the slide carousel could be individually selected by the operator. Details of the console map background capability are discussed under the applicable requirement in b below.

(4) Photochromic - data entry and edit module (DEEM) and data control unit (DCU).

(a) The DEEM used a magnetically deflected, single color (green) CRT display. The 16-inch diameter CRT was produced by Thomas Electronics.

(b) The DEEM used a stroking technique with a maximum refresh rate of 60 hertz to display alphanumeric, graphic, and military unit symbology in a single color. The CRT was rear-ported and it used a Kodak Ektographic RA-960 slide projector to display map backgrounds on the screen. The map image area was 10 inches wide and 7 1/2 inches high. Details of the DEEM map background capability are discussed under the applicable requirements in b below.

(c) The interactive controls for the DEEM were located on a separate device, the DCU. The DCU was designed primarily to control the group display. When the DEEM was made a part of the system, the functions of the DCU were modified to include control of the DEEM. The DCU contained a 64-character ASCII keyboard, pushbuttons for alphanumeric, military unit, and graphic symbols and indicator lights for various system functions. When a pushbutton was pressed, an audio feedback (beep) assured the operator that the pushbutton contact was positive. The DCU also included a joystick which controlled the movement of a cursor.

(d) A switch was used to indicate the device controlled by the DCU. All manipulations performed at the DCU affected displays on the group display device when the switch was in one position, and displays on the DEEM were affected when the switch was rotated to a second position.

b. Evaluation.

(1) Evaluation for requirement number 1.

(a) Requirement 1. The console must be able to display the 64-character ASCII set; the FM 21-30 symbols listed below; symbology added to the symbol generator by the user; circles; ellipses; and free-hand graphics such as symbols for boundaries and axis of advance. The following symbols should be a part of the permanent symbol generator. FM 21-30 illustrates each symbol and provides examples of the use of the symbols.

Military Unit Symbols

HEADQUARTERS
CENTER OF MASS
TRAIN

NOTE: Military unit symbols must be displayed as actual or proposed. In addition, they must denote whether the represented unit is a task force.

Branch Duty Symbols

AIRBORNE	ARMOR	ENGINEER
AIR DEFENSE ARTILLERY	AVIATION	INFANTRY
AIRMOBILE	CAVALRY	MAINTENANCE
ANTITANK	CHEMICAL	PSYCHOLOGICAL OPERATIONS
FIELD ARTILLERY	ENGINEER, BRIDGE	SIGNAL
		TRANSPORTATION

Graphic Symbols

OBSERVATION POST	AMMUNITION SUPPLY POINT, ALL TYPES (combat service support installation)
COORDINATING POINT	
MINE, ANTITANK	
MINE, ANTIPERSONNEL	AID STATION (combat service support installation)
POL POINT, GROUND (combat service support installation)	

Line-Type Graphic Symbols

SOLID LINE	DASHED LINE
TRENCH, BASIC SYMBOL	TANK OBSTACLE, TYPE UNSPECIFIED
WIRE, CONCERTINA, SINGLE	LINE OF CONTACT (defensive frontline trace)

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met (EC)	Met	Met
Met (AC)		

(c) Discussion. The list of symbols which the scribe and the CRT systems were capable of displaying was mutually agreed upon by MASSTER and each vendor. The list of symbols did not include all of the symbols specified by the requirement. However, the scribe and the CRT systems were able to display the symbols agreed upon. The photochromic system was able to display the symbols specified by USAMC-ECOM. All three systems would have had the required symbols in their symbol library if the designers had been given the above list. Therefore, all three systems were rated as having met the intent of the requirement.

(d) Data. The number of symbols which were contained in each system's symbol library are shown in figure 2-4.

Symbol	Required	Scribe	CRT	Photochromic
Alphanumeric	64*	64*	64*	64*
Military unit Type	3	5	5	5
Branch duty	16	41	13	25
Individual graphic	7	16	7	6
Line-type graphic	6	4	2	4

*The symbols were the same as those contained in the 64-character ASCII set.

Figure 2-4. Number of symbols in console symbol library.

(2) Evaluation for requirement number 2.

(a) Requirement 2. A minimum of three colors is required. Three colors allow friendly, enemy, and control measure symbols to be color coded. Four to six colors are desirable. Color selection must be based upon obtaining a high degree of contrast in relation to the map backgrounds the symbols will be displayed upon.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	No	No
No (AC)		

(c) Discussion.

1 Scribe. Both the analyst console and the editing console presented single color displays. The consoles had no potential for displaying more than one color. Shape coding was used to distinguish between friendly and enemy military unit symbols. The enemy military unit rectangle had a notch or dovetail in place of the right vertical edge. The consoles had no map background display capability. Therefore, the contrast of the symbol color against map backgrounds could not be determined.

2 CRT. The analysis console had the hardware potential for a four color display. System design allowed for only two of four possible voltage inputs to the CRT anode. This resulted in a two color display. In addition to color, enemy military unit symbols were distinguished by a notch or dovetail in place of the right vertical edge of the symbol rectangle. Data, however, indicated that color was the primary distinguishing factor used by observers of the display and that shape coding was unnecessary when color was used. Contrast of the red and green symbols against the level 4 and level 6 map backgrounds was satisfactory. The projection of the standard military topographic map was predominantly white, and contrast of the symbols (especially red) against this background was low.

3 Photochromic. The DEEM had a one color display. It had no potential for displaying more than one color. Enemy military unit symbols were distinguished by a double edged rectangle. Contrast of the green dynamic symbology against the CRT system's level 4 and level 6 map backgrounds was satisfactory. The contrast against the standard military topographic map was also satisfactory.

(3) Evaluation for requirement number 3.

(a) Requirement 3. The operator should be able to easily identify any symbol on the display while working under normal office lighting (70 foot-candles at desk top level). Full legibility with desk lamps only at each work space is marginally acceptable.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met (EC)	Met	Met
Met (AC)		

(c) Discussion. Symbols on the CRT and photochromic consoles were displayed against a map background (level 6 for the CRT and standard military topographic map for the photochromic). The symbols on the scribe consoles were not displayed against a map background since they did not have a map background display capability.

1 Scribe. The operator could easily identify the symbols and work comfortably for several hours under the 70 foot-candle light condition.

2 CRT. A light level much lower than 70 foot-candles was required for comfortable viewing. The operator could easily identify the symbols and could work comfortably with:

- a Desk lamps only and no overhead light.
- b Desk lamps off and the overhead ambient lights set for approximately 1 to 3 foot-candles at desk top level.

3 Photochromic. The operator could easily identify the symbols and work comfortably for several hours under the 70 foot-candle condition.

(4) Evaluation for requirement number 4.

(a) Requirement 4. The symbol size should be variable upon operator request. However, the console must be designed with one optimum symbol size in mind.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met (EC)	No	No
Met (AC)		

(c) Discussion.

1 Scribe. The system had eight discrete symbol sizes. Whenever a new size was selected, the size of all symbols in the display changed. The apparent locations of the symbols remained the same when the size of the display was changed.

2 CRT. Two discrete sizes of alphanumeric and military unit symbols were available. However, size change could be effected for individual symbols only. Changing the size of the entire display required the operator to individually change the size of every symbol in the display.

3 Photochromic. Only one symbol size was available.

(5) Evaluation for requirement number 5.

(a) Requirement 5. The console display area must be large enough to display a tactical situation (maximum of 75 military unit symbols for a division) with a minimum amount of symbol clutter, but it must not be so large that it causes the operator undue eyestrain or head movement.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	Met	No
Met (AC)		

(c) Discussion.

1 Scribe. The size of the EC screen was rated as too small by the CPX players because of symbol clutter when the overall division situation was displayed. Although clutter could be reduced by changing to a smaller symbol size, the smaller symbol size reduced the legibility of the symbols, especially the alphanumerics. The same CPX players rated the AC screen size as satisfactory.

2 CRT. The size of the analysis console, although rated as meeting the requirement, was marginal for the symbol size used. The display was rated incomprehensible when the total number of military unit symbols exceeded 50. When placed as close as possible, with no overlap, 72 friendly or 66 enemy military unit symbols filled the screen. This screen symbol capacity met player requirements during the CPX as the maximum number of symbols used during the CPX was 36.

3 Photochromic. The DEEM screen was rated as too small because of symbol clutter when the overall division situation was displayed. No provision was available for reducing clutter by changing symbol size.

(6) Evaluation for requirement number 6.

(a) Requirement 6. The displayed symbology must not have any discernible flicker.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met (EC)	Met	Met
Met (AC)		

(c) Discussion. Flicker was not discernible on the scribe and photochromic consoles. Slight (but not distracting) flicker occurred on the CRT console when a display containing a large number of symbols (approximately 75 data items) was also displayed on the group display. This could have been precluded by having separate refresh buffer units for the analysis console and the group display rather than using one buffer for both devices.

(7) Evaluation for requirement number 7.

(a) Requirement 7. The brightness of each color of dynamic symbology and each color representing a map data feature should be controllable by the console operator. As a minimum, the operator must be able to vary the overall brightness of the dynamic symbology and the overall brightness of the map background.

(b) Performance.

<u>Scribe</u>	<u>CRI</u>	<u>Photochromic</u>
NA (EC)	No	Met
NA (AC)		

(c) Discussion.

1. Scribe. The editing and analyst consoles had an operator-controlled knob for varying the brightness (intensity) of their symbology. The consoles had no map background display capability.

2. CRT. The analysis console had a knob with which the operator could control the intensity of both dynamic symbology colors at the same time. There were no individual color brightness controls. The console did not have a control for varying the brightness of the displayed map background.

3. Photochromic. Separate control knobs which controlled the brightness of the dynamic symbology (the DEEM had only one color) and the brightness of the displayed map background were provided on the DEEM.

(8) Evaluation for requirement number 8.

(a) Requirement 8. Fully automatic declutter (offset) without affecting currently displayed symbols upon initial display (regardless of whether manually created or received from TOS) of any symbol for a military unit, spot report, sensor locations, etc., is required. The declutter lines must be directly attached to the symbol.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	No	NA
No (AC)		

(c) Discussion.

1 Scribe. The system automatically decluttered data input from DEVTO~~S~~. Symbols input by the operator at the consoles had to be manually decluttered. Declutter lines were not attached to military unit symbols. Comprehension of a scene containing a number of military unit symbols and declutter lines was difficult since the observer had to determine which symbol was associated with each declutter line.

2 CRT. The system automatically decluttered data input from DEVTO~~S~~. Symbols input by the operator at the console had to be manually decluttered. Declutter lines were attached to the symbols.

(9) Evaluation for requirement number 9.

(a) Requirement 9. The operator should be able to cause a complete, automatic redeclutter of the display. The redeclutter should relocate symbols based upon the criteria of the shortest possible declutter lines and no symbol overlap. Each symbol should be considered equally. Priority of entry should have no effect.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. This requirement was identified as a result of the experimentation.

(10) Evaluation for requirement number 10.

(a) Requirement 10. Co-located military unit headquarters must be automatically stacked before being decluttered upon initial display.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	NA	NA
No (AC)		

(c) Discussion. The scribe console allowed for stacking of co-located military unit symbols, but the stacking was not automatic. The operator was required to determine which symbols were co-located and then to use the stacking function.

(II) Evaluation for requirement number II.

(a) Requirement II. Data items superimposed against a map background on the interactive graphic display console must appear to be no more than 100 meters from the specified map location. This 100-meter limit applies for any method of data item location: keyboard coordinate entry, coordinates transmitted from an outside ADP source, points transmitted from the map overlay input device, or direct entry by pointing to the location on the console display. The limit applies regardless of the size of the area of coverage being viewed.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	No	No
No (AC)		

(c) Discussion.

1 Scribe. Since the editing and analyst consoles had no map background display capability, symbol placement accuracy was approximated by using the computer generated tick marks as references. Accuracy of the trackball and light pen on the analyst console was found to be totally unacceptable (placement inaccuracies ranged from 700 meters to 11,000 meters), and data collection for placement inaccuracies involving these controls was terminated. The lack of a map background severely affected joystick placement accuracy on the editing console.

2 CRT. The factor which had the greatest effect on symbol placement accuracy was registration of the projected map image to match the electronically defined map area on the console screen. Accuracy was also affected by distortion of the map image at the lower left and lower right corners since the lower edge of the map was not straight, but curved, turning in at the corners.

3 Photochromic. The comments made for the CRT system apply except for those on background distortion.

(d) Data. Average symbol placement inaccuracies for different methods of data item location are shown in figure 2-5. Detailed data is contained in part three, sections V, XVIII, and XX.

Method of input	Scribe		CRT	Photochromic
	EC	AC		
DEVTO5	464	511	167	NA
Overlay input device	NA	NA	197	NA
Data manipulation				
Keyboard, add	470	434	159	337
Keyboard, move	465	347	175	322
Joystick, add	834	NA	NA	61
Joystick, move	949	NA	NA	67
Trackball, add	NA	No data	102	NA
Trackball, move	NA	No data	65	NA
Light pen, add	NA	No data	106	NA
Light pen, move	NA	No data	78	NA

Figure 2-5. Console symbol average placement inaccuracy (meters).

(12) Evaluation for requirement number 12.

(a) Requirement 12. Exact entry coordinates of data item locations entered by keyboard or by coordinates from an outside ADP source must be displayed upon request.

(b) Performance.

Scribe	CRT	Photochromic
NA (EC)		
NA (AC)	Met	No

(c) Discussion.

1 Scribe. Although the system did not have this capability, the capability could have easily been incorporated.

2 CRT. The system displayed the coordinates of the symbol upon request.

3 Photochromic. The system displayed the coordinates of the symbol, but the coordinates were not exact as the operator had to manually position a cursor at the point where the symbol was located. The system then displayed the cursor location coordinates.

(13) Evaluation for requirement number 13.

(a) Requirement 13. For data items entered by pointing, as well as locations entered via the map overlay input device, the coordinate provided in reply to a query must be no more than 100 meters from the data item's apparent map location.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. This requirement was identified as a result of the experimentation; thus, no placement accuracy data was collected. However, the CRT and photochromic consoles were both able to provide the coordinates of a displayed symbol by using the capability discussed in requirement 12.

(14) Evaluation for requirement number 14.

(a) Requirement 14. Data items located with single points must be completely displayed if the point is inside the selected area of coverage. This may require the automatic decluttering of the data item to ensure that the entire item appears in the area of coverage such as when a military unit is at the top edge of the background. If any part of a multiple-point data item is in the selected area of coverage, that part within the area of coverage must be displayed. The part to be displayed must include all points of the data item up to and including those at the intersection of the item with an edge of the map background.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	No	NA
No (AC)		

(c) Discussion.

1. Scribe. The consoles displayed only the portions of single location point symbols that were within the selected map area of coverage. Multiple-point symbols (such as lines) which had one or more locating points outside the area of coverage were not displayed.

2. CRT. The console displayed a symbol only if all portions of the symbol were within the selected map area of coverage. Multiple-point symbols (such as lines) which had one or more locating points outside the area of coverage were not displayed.

(15) Evaluation for requirement number 15.

(a) Requirement 15. Incoming messages (from an outside ADP source) which contain branch duty symbols not in the system's permanent branch symbol library, must display at least the first four alphanumeric characters of the branch duty designation (from the incoming messages) inside the rectangle where the branch duty symbol normally appears.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	Met	NA
NA (AC)		

(c) Discussion.

1 Scribe. The system's symbol library contained all of the symbols necessary for messages transmitted from DEVTOS. The capability needed to fulfill the requirement could have been incorporated easily.

2 CRT. The system displayed the first four characters of the branch duty designation inside the rectangle.

3 Photochromic. The system was not designed to receive data from DEVTOS.

(16) Evaluation for requirement number 16.

(a) Requirement 16. An interactive graphic display console must be capable of displaying map backgrounds for the three uses described below:

1 Comprehension of the overall situation. For this purpose the user is not interested in being able to read all detail on the standard military topographic map, but he uses the map to provide general orientation for the superimposed symbology.

2 More detailed inspection of the terrain at or in the vicinity of a superimposed symbol or symbols. In this case the user is interested in a more exact relationship of the symbols to the terrain.

3 Terrain analysis without superimposed symbology. For example, when selecting the best terrain upon which to establish a defense or when planning a route of movement, the user wants to view the map background with no superimposed dynamic symbology.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	No	No
NA (AC)		

(c) Discussion.

1 Scribe. The inability of the consoles to display backgrounds with which the user can orient the symbology to the terrain was a serious shortcoming.

2 CRT. The console did not demonstrate the ability to legibly display map backgrounds to meet the uses described in (a)2 and (a)3 above.

3 Photochromic. The console did not demonstrate the ability to legibly display map backgrounds to meet the uses described in (a)2 and (a)3 above.

(17) Evaluation for requirement number 17.

(a) Requirement 17. Map backgrounds based on the UTM grid system will normally be displayed on the console. However, the console should be able to accommodate other military grid systems. The UTM grid system requires that the console be able to display areas of coverage which include the junction of two or more map sheets and the junction of two or more 100,000-meter grid zones.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	Met	Met
NA (AC)		

(c) Discussion. Map backgrounds displayed on the CRT and photochromic systems used the UTM grid system. The maps displayed included the junction of map sheets and the junction of 100,000-meter grid zones.

(18) Evaluation for requirement number 18.

(a) Requirement 18. The console must be able to display an area of coverage large enough to permit superimposing dynamic symbology for most user tactical situations displays. User data indicates that an area at least 50 kilometers by 50 kilometers is required for an overall situation display of an armored or mechanized division. The console screen must be designed to provide this area of coverage.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	No	No
NA (AC)		

(c) Discussion. This requirement was identified as a result of the experimentation. A 40-kilometer by 40-kilometer area of coverage was agreed upon at the map conference.

1 CRT. Technical limitations of the photographic equipment at the Defense Mapping Agency limited the size of the map slides to a 32-kilometer by 32-kilometer area of coverage.

2 Photochromic. The map slides provided with the photochromic system had a 27-kilometer by 36-kilometer area of coverage which was specified by USAMC-ECOM.

(19) Evaluation for requirement number 19.

(a) Requirement 19. It is assumed that the screen is within arm's reach of the operator. The operator must view the entire screen image area from this distance without undue eye and head movement.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	Met	Met
NA (AC)		

(c) Discussion.

1 CRT. The console on the CRT system marginally met this requirement. The screen's height required a seated operator to look slightly upward to view the entire screen image. The screen's height also caused the operator to reach up higher than he normally would in pointing to items on the display.

2 Photochromic. The console marginally met this requirement. The console screen and keyboard were separate pieces of equipment. The screen was located on the operator's left when he was seated at the keyboard. This caused the operator to turn his head frequently to view the screen.

(20) Evaluation for requirement number 20.

(a) Requirement 20. When the user changes the area of coverage displayed on the screen, user specified dynamic symbology in the new area of coverage must be automatically displayed on the new area at the appropriate map locations. This requirement applies if the new area is a magnification of a small portion of the old area, if it includes all or a portion of the old area, or if it does not include any portion of the old area.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met (EC)	Met	No
Met (AC)		

(c) Discussion.

1 Scribe. The system met the intent of the requirement, as changing the area of coverage defined on the console screens caused the automatic display of data items located in the new area. The display was not always complete. (See requirement 14.)

2 CRT. Display of a different map background caused the automatic display of data items located in the area defined by the new background. The display was not always complete. (See requirement 14.)

3 Photochromic. Changing the displayed area of coverage required the re-creation, one data item at a time, of the tactical situation for the new area.

(21) Evaluation for requirement number 21.

(a) Requirement 21. Map backgrounds displayed on the console screen must be fully legible under the ambient light specified in requirement 3 above for dynamic symbology legibility. Full legibility is defined as the ability of the operator to easily identify each and every item of map data displayed.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	No	No
NA (AC)		

(c) Discussion.

I CRT.

a The level 4, level 5, and level 6 maps provided legible map data which allowed comprehension of the overall situation. The amount of data on the level 3 map was excessive. The map was overly cluttered and was unacceptable. The legibility of the fine map detail on the standard military topographic map was unacceptable for detailed terrain analysis. When the standard military map was displayed, intermediate contour lines and small alphanumerics on the map were not legible and grid line numbers were barely legible. In addition, the brightness of the map projection caused low contrast with the dynamic symbology and tended to wash it out. The standard topographic military map, the orthopictomap, the joint planning map, and the level 3 map were not used during the CPX; player preference was for the level 4, level 5, or level 6 map backgrounds.

b The legibility of the standard military topographic map, the level 4 map, the level 6 map, and the orthopictomap was tested in work segment 7. (See part three, section VII.) All map detail on the level 4 and the level 6 maps was highlighted and was fully legible under the required lighting conditions. The smallest alphanumerics on the standard topographic military map and the orthopictomap were not legible. They were not legible even when the operator was at the face of the screen and the ambient light was set for maximum viewability of the map background.

2 Photochromic. The standard military topographic backgrounds displayed on the console were not fully legible and could not be used for detailed terrain analysis. Although no maps were available which were designed specifically for comprehension of the overall situation, the displayed standard military topographic map backgrounds could be used for this purpose.

(22) Evaluation for requirement number 22.

(a) Requirement 22. The console operator should be able to vary the brightness of each color representing a map feature (e.g., roads, vegetation, rivers). He must, as a minimum, be able to vary the overall brightness of the map background.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	No	
NA (AC)		Met

(c) Discussion.

I CRT. The console did not have a control for varying the brightness of the displayed map background.

2 Photochromic. The console met the minimum requirement. A control was available to vary the brightness of the entire map background.

(23) Evaluation for requirement number 23.

(a) Requirement 23. Ideally, the user should be able to obtain the desired area of background coverage by providing the system with the coordinates of any two diagonal corner points.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. This requirement, which is the ideal solution for providing the desired area coverage, was identified as a result of the experimentation.

(24) Evaluation for requirement number 24.

(a) Requirement 24. The operator must have the option of numbering or otherwise identifying a map background area which he defines by two diagonal corner points.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. This requirement was identified as a result of the experimentation.

(25) Evaluation for requirement number 25.

(a) Requirement 25. Ideally, the user should be able to tailor the level of map detail to the situation by being able to display specific map features (grid lines, roads, contours, rivers, etc.) individually, or in combination, for the defined area of coverage. For each specific map feature, the user should be able to select more or less detail (e.g., grid lines 1, 5, or 10 kilometers apart; primary roads only, or primary and secondary roads; or contour intervals of 100, 200, or 500 meters).

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. This requirement expresses the ideal solution for providing the desired level of map detail.

1 CRT. Discrete maps that displayed varying levels of detail were available, but this solution was not ideal since the user was limited to the predetermined levels of map detail.

2 Photochromic. The only map background available was the standard military topographic map with full detail. Not all of the detail on this map was legible on the console.

(26) Evaluation for requirement number 26.

(a) Requirement 26. The available backgrounds must be on-line and retrievable within 15 seconds. The capability to retrieve and display a background within 5 seconds is highly desirable. Additionally, the user must be able to add to or delete from the number of available backgrounds.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	Met	Met
NA (AC)		

(c) Discussion. The CRT and photochromic consoles were reported and used Kodak Ectagraphic projectors. Each projector had 80 computer-addressable slide positions with an average access time of 5 seconds.

(27) Evaluation for requirement number 27.

(a) Requirement 27. Registration of a new background (i.e., defining for the system the limits of the area) must require the operator to only point at and input the UTM coordinates of any two grid intersections diagonally located in relation to each other. The background must not have to be exactly horizontal, vertical, or centered. Once registered, the background must be available for display without reregistration each time it is retrieved.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NO	No
NA (AC)		

(c) Discussion. The designers of the CRT and the photochromic systems assumed that the map background slides (film chips) would be exactly the same size and that they would be positioned in the slide holder exactly the same way. They further assumed that the slides would be exactly horizontal and vertical in the holder. These assumptions, while good for the convenience of the system software designer, imposed an unrealistic requirement which could not be met by the Defense Mapping Agency. The slides prepared by DMA were not positioned identically in the slide holders. Therefore, display of a new map background required realignment of the electronic image to match the map background each time a different map was displayed. This was an unnecessary burden on the user and defeated the purpose of having rapidly accessible backgrounds.

I CRT.

a The system did not allow for user registration of map backgrounds. The system programmer could register a new map area by means of a software patch, but the normal means was to input the map registration data to a computer at the General Dynamics Laboratory in San Diego, California. The computer computed the registration data which was then input to the display system.

b All maps displayed by the system were part of a "big window." The big window was a square area which encompassed all of the maps displayed by the system. If a map to be registered was not within the big window, the area of the big window required enlargement.

c Each map in the big window was identified by a number. The lower-left corners of the maps in the big window were identified by their X and Y offset from the lower left corner of the big window. All UTM coordinates were converted to big window coordinates. Conversion was based on the X-Y offset, the scale of the map, and the area of coverage of the map. The area of coverage was assumed to be square.

d A map, once registered, did not need to be re-registered when retrieved. However, the map images, when retrieved, had to be exactly horizontal, vertical, centered, and to scale. This was an unrealistic requirement.

2 Photochromic.

a The system assumed that the map chip was positioned in the slide a specific way. The registration of a displayed map area required the operator to enter data which matched the map image area on the console screen with the displayed map image. The operator typed in the coordinates of the lower left corner of the map area (with a correction factor in X and Y to account for the fact that the corner was not exactly at a grid line intersection). The coordinates included the area of the world (e.g., 14R), the 100,000-meter grid zone designator (e.g., PL), and eight digits. The operator then typed the map scale and the four adjacent 100,000-meter grid zone designators. These grid zone designators were the designator previously entered as a part of the lower left coordinate and the grid zone designators to the north, east, and northeast.

b When map background areas were changed, the new map area required re-registering even though it may have been previously retrieved and registered.

(28) Evaluation for requirement number 28.

(a) Requirement 28. Backgrounds to be used for display of the overall division situation must have an area of coverage no less than 50 kilometers by 50 kilometers.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	No	No
NA (AC)		

(c) Discussion. The comments made for requirement 18 apply.

(29) Evaluation for requirement number 29.

(a) Requirement 29. The map data on maps used for comprehension of the overall situation (requirement 16) must be enhanced or highlighted. Letters and numbers may have to be larger than those found on the standard military topographic map.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	Met	No
NA (AC)		

(c) Discussion.

1 CRT. Data on the level 4, level 5, and level 6 maps was highlighted. Letters and numbers were larger than those found on current paper maps. These maps could be used for comprehension of the overall situation and were fully legible.

2 Photochromic. The only map backgrounds provided with the system were standard military topographic maps. Not all map detail was fully legible on the console display of these maps.

(30) Evaluation for requirement number 30.

(a) Requirement 30. Backgrounds with selected combinations of map detail are required.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	Met	No
NA (AC)		

(c) Discussion. The CRT console was the only console which had map backgrounds that showed varying levels of detail. The requirement for varying levels of detail was identified as a result of the experimentation. However, the selected combinations of map data which should be made available require more study. The level 3 map was too cluttered to be of use. The standard military topographic map was not legible enough when displayed. Some users were satisfied with the level of detail on the level 6 map when it was used to view the overall tactical situation. Others desired more detail but not as much as that found on the level 5 map.

(31) Evaluation for requirement number 31.

(a) Requirement 31. Background coverage overlap must be provided.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	Met	
NA (AC)		Met

(c) Discussion.

1 CRT. The 50 percent overlap that was provided appeared to be satisfactory to the players during the CPX. However, this amount of

overlap may not be the most efficient. A study is required to determine the best means of providing continuity of background coverage when discrete map background areas are used.

2 Photochromic. The maps provided by this system had a 33 percent overlap. Since a CPX was not run with this system and since the system could not automatically display the appropriate dynamic symbology for the new area when map areas were changed, the utility of the overlap was not tested.

(32) Evaluation for requirement number 32.

(a) Requirement 32. Backgrounds which magnify smaller portions of the 50-kilometer by 50-kilometer backgrounds must be provided. A sufficient number (four to nine may be sufficient depending upon the size of the screen and the map area of coverage) of blowups should be available so that the composite area of each 50-kilometer by 50-kilometer background can be shown in magnified form. The blowups need not overlap but must contain no less detail than that found on the 1:50,000 scale topographic map. When the blowups are displayed, they must be fully legible.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. Backgrounds were not provided for this purpose. The map conference focused on map requirements for the display of the overall tactical situation. However, both the scribe and CRT systems could scale the display of the dynamic symbology to match any map background magnification factor.

(33) Evaluation for requirement number 33.

(a) Requirement 33. The console operator must be able to add, delete, correct, move, and declutter (offset) any tactical situation display data item. Instantaneous visual feedback of the operator's actions is required for all manipulations.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	Met	No
No (AC)		

(c) Discussion.

1 Scribe. The console operator had procedures for adding, deleting, moving, and decluttering displayed symbols. When a symbol was decluttered, the declutter line was not attached to the symbol. Correction of a symbol required that the symbol first be deleted, then the correct symbol be entered by using the procedure for adding symbols. Instantaneous visual feedback was provided for all manipulations except delete. When deleting a displayed symbol, a regeneration of the display was required to verify that the symbol was, in fact, removed from the display.

2 CRT. The console operator had procedures for adding, deleting, correcting, moving, and decluttering displayed symbols. Instantaneous visual feedback was provided for all manipulations.

3 Photochromic. The console operator had procedures for adding, deleting, and correcting symbols. Movement and declutter of symbols required that the symbol first be deleted, and then input again by using the procedure for adding symbols. Instantaneous visual feedback was provided for all manipulations.

(34) Evaluation for requirement number 34.

(a) Requirement 34. The console operator must have some means for positioning newly created or moved data items. There are two basic methods for positioning a data item. One method is the use of a map background to "eyeball" the desired location. This position is then indicated to the system by pointing. The other method is by keyboard entry of the coordinates. The console must give the operator the option of using either method. The first method is generally used when the exact location is not critical or when the position needs to be determined through map inspection. Coordinate entry is used for those items with specific coordinates. Coordinate entry must not require grid zone designation (entry of grid zone designation should be optional). Additionally, it must allow a 4-, 6-, or 8-digit entry depending upon operator preference. The map currently displayed can be used by the system to interpret the coordinates entered by the operator.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met (EC)	Met	Met
No (AC)		

(c) Discussion.

1 Scribe.

a Data items could be positioned on the editing and analyst consoles by typing in the UTM coordinates on the keyboard. A coordinate entry consisted of a 100,000-meter grid zone designator and eight digits. The editing console also had a joystick-controlled cursor which could be used to point to the location of a symbol.

b The analyst console had a light pen and a trackball which controlled a cursor for pointing. Although the console had these means for positioning data items, the placement accuracies were unacceptable when the light pen and the trackball were used. (See requirement 11.)

2 CRT. The console had three methods of positioning data items. One method was the typing of the UTM coordinates at the keyboard. A coordinate entry consisted of a 100,000-meter grid zone designator and eight digits. The two other methods available were the use of a light pen and a trackball which controlled a cursor for pointing to a location.

3 Photachromic. Two methods were available for positioning data items. One method was the typing of the UTM coordinates at the DCU keyboard. A coordinate entry consisted of an area of the world designator (e.g., 14R), a 100,000-meter grid zone designator, and eight digits. A second method was the use of a joystick-controlled cursor for pointing. The joystick was located on the DCU.

(35) Evaluation for requirement number 35.

(a) Requirement 35. Some means for indicating which item in the display is to be deleted, corrected, moved, or decluttered is required. The preferred method is to point at the item. Ideally, the operator should be able to indicate which item is to be manipulated by touching it with his finger, provided the technology, cost, and complexity of implementation support this method. Other less desirable (but state-of-the-art) methods for pointing are light pens and trackball- or joystick-controlled cursors.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photachromic</u>
Met (EC)	Met	Met
No (AC)		

(c) Discussion.

1 Scribe. The same means available for positioning items (requirement 34) were available for indicating the symbol to be manipulated.

2 CRT. The light pen was used to point to the symbol which was to be moved, corrected, decluttered, or deleted.

3 Photochromic. The joystick on the DCU was used to move a cursor to the location of a symbol which was to be corrected or deleted.

(36) Evaluation for requirement number 36.

(a) Requirement 36. The system must lead the operator through each key step of the operating procedure. For example, if function pushbuttons are used, the system could be programmed to light appropriate pushbuttons to show the operator his choice of alternatives at each step in the procedure. In this case, the pushbuttons should be in a color selected to identify them as available alternatives and to differentiate them from pushbuttons which are merely activated.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	Nc	
No (AC)		No

(c) Discussion.

1 Scribe. The system had no means for leading the operator through the operating procedures. The operating procedures required the operator to enter typed alphanumeric commands. The alphanumeric commands contained specific fields to describe the desired result. The major disadvantage of these procedures was the difficulty in learning the legal alphanumeric codes applicable to the fields in each command. Once the alphanumeric codes were learned, however, the use of the commands was straightforward and relatively rapid. Another disadvantage was the lack of an instantaneous visual feedback when a symbol was deleted.

2 CRT. The CRT console operator used a light pen and a function menu (displayed on the right side of the console screen when the MODIFY function pushbutton was depressed) to perform most of the console operating procedures. The procedures required a sequence of picks with the light pen from the function menu. The operator needed to know the sequence of picks and the legal picks for each step of a procedure. There were two disadvantages. First, the operator was not led through the sequence of picks. This made the learning of the procedure difficult and error filled for an unfamiliar operator. It would have been helpful if for each step in a procedure sequence a blinking marker had indicated which items in the menu the operator could pick next. An even more user-oriented alternative would have been individual menus which displayed only the choices for each successive step in an operational sequence. The other disadvantage was that many of the procedures required numerous steps. However, once the operator was thoroughly familiar with the procedures, they were not difficult to use. The instantaneous visual feedback for all manipulations was a very desirable feature.

3 Photochromic. The photochromic system required function push-buttons to be pressed in a specified sequence for each procedure. Although the system did not meet the requirement, the procedure for creating military unit symbols led the operator through the function pushbutton sequence by positioning the cursor at the part of the symbol (e.g., the echelon) the operator needed to create next. The major advantages of the procedures were the ease with which they were learned, the straightforward use of the pushbuttons, and the instantaneous visual feedback for the manipulations. The grouping of the function pushbuttons (e.g., all echelon pushbuttons together) aided the operator in locating the appropriate pushbutton.

4 General. The same console operator, an Army specialist fourth class, was used for all three systems. His preference was for the photochromic system procedures because of their ease of use. A description of the step-by-step operating procedures for the three systems is contained in part three, section XX.

(37) Evaluation for requirement number 37.

(a) Requirement 37. Data item creation should require a procedure similar to that listed below:

1 Press the CREATE data item pushbutton.

2 Select the categories the data item will be a member of by pressing the appropriate category pushbuttons. (See requirement 47 below.)

3 Press one of three data type pushbuttons: A/N, MILITARY SYMBOL, or GRAPHIC.

4 Press the desired color pushbutton (e.g., RED for red).

5 Point to the desired location on the screen or type in the coordinate location. (There should be visual feedback whenever a coordinate is being typed.)

6 Create the desired item by using the procedure discussed in the following subparagraphs for that data type.

a Alphanumerics.

(1) Alphanumerics are most effectively created with the ASCII keyboard. A special key for the coordinate position dot associated with some alphanumerics (e.g., • TANK, • TRUCK) must be provided, since the

ASCII period does not stand out and its location is generally not precise. A marker must appear on the screen to indicate to the operator the position of the next character to be added.

(2) The ability to space left, right, up, and down is required to allow the operator to format the data item to suit his needs. He must also be able to backspace in order to make corrections.

b Military unit symbols.

(1) In creating military unit symbols, pushbuttons should be used to select a headquarters, center of mass, or trains symbol. If the symbol is to depict a proposed or task force symbol, the appropriate pushbuttons should be pressed. Branch duty symbol selection is then accomplished by pressing a pushbutton. The following branch duty symbol pushbuttons should be provided:

AIRBORNE	ARMOR	ENGINEER
AIR DEFENSE ARTILLERY	AVIATION	INFANTRY
AIRMOBILE	CAVALRY	MAINTENANCE
ANTITANK	CHEMICAL	PSYCHOLOGICAL
FIELD ARTILLERY	ENGINEER, BRIDGE	OPERATIONS
TRANSPORTATION		SIGNAL

(2) At least 10 additional pushbuttons must be provided for operator created branch duty symbols. (See requirement 42 below for creation procedures.) The operator must have the option of superimposing at least two branch symbols (e.g., armor, infantry) in the creation of a military unit symbol. An easily identifiable point such as the lower left corner of the flag should be established as the location of flag symbols with no staffs. The system should lead the operator through the addition of the left and right identifications and the echelon. A marker must advance automatically to each of these locations. Each location must allow for the entry of up to four ASCII characters.

c Graphics.

(1) The creation of graphic items such as boundaries, frontline traces, trench lines, and freehand symbols by a series of short line segments must be possible by both pointing and coordinate location. The procedure should require only that the operator specify the points of inflection, the end point, and the type graphic (e.g., solid line, dashed line, trench symbol) being created. The following line-type graphic symbol pushbuttons should be provided:

SOLID LINE	DASHED LINE
TRENCH, BASIC SYMBOL	TANK OBSTACLE, TYPE UNSPECIFIED
WIRE, CONCERTINA, SINGLE	LINE OF CONTACT (defensive front-line trace)

At least two additional pushbuttons must be provided for operator created line-type graphic symbols. (See requirement 44 below for creation procedures.) The system should automatically connect the points with the line type selected. In the case where pointing is used to specify coordinate location, it is desirable to have a rubber band line segment effect which allows the operator to see where the line will be before fixing the inflection point.

(2) The creation of circles or ellipses should be indicated to the system by pressing the CIRCLE or ELLIPSE pushbutton. The operator then indicates the radius or major and minor axes by pointing to their particular locations on the screen. A continuously visible size variation ability at this point is desirable.

(3) The creation of individual graphic symbols such as mines and control points should use pushbuttons for the selection of the desired symbol. The following graphic symbol pushbuttons should be provided:

OBSERVATION POST	AMMUNITION SUPPLY POINT, ALL TYPES
COORDINATING POINT	(combat service support installations)
MINE, ANTITANK	AID STATION (combat service support
MINE, ANTI PERSONNEL	installation)
POL POINT, GROUND (combat service support installation)	

At least five extra pushbuttons must be provided for operator created individual graphic symbols. (See requirement 43 below for creation procedures.) The coordinate location of the symbols will be assumed to be at their center.

7 If the operator desires to start over at any point, he should only have to press the ABORT pushbutton. This returns the console to the operational state it was in before the CREATE pushbutton was pressed.

8 Press the COMPLETE pushbutton. This should leave the previously selected CREATE, category, symbol type, and color pushbuttons lit. The operator can then create several data items of the same type without reselection. He should also have the option of reselecting categories, symbol type, or color at any time before the COMPLETE pushbutton is pressed. The CREATE pushbutton will remain activated until the operator turns it off.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	No	No
No (AC)		

(c) Discussion.

1 Scribe.

a The procedure for creating alphanumerics met the degree of ease specified by the requirement. It only required typing "W," the UTM coordinate location of the alphanumeric ("X" was typed if the location was to be indicated by movement of the cursor rather than UTM coordinates), and the alphanumeric. The ASCII period was used as the locating dot for the alphanumeric. The period was difficult to see.

b Military unit symbols and graphics (including circles and ellipses) were created by typing an alphanumeric command which contained up to 10 separate fields that the operator filled in. The legal entries for the field were difficult to learn and remember.

2 CRT.

a In general, the procedures for data item creation required too many steps. An example of this was the creation of a military unit symbol which required a minimum of seven picks with the light pen from the "modify" menu to create the rectangle and one branch symbol. The operator then had to use the keyboard to enter the left identification, the right identification, and the echelon. When the symbol was complete, the item was entered into the system data base by picking "fix item" from the menu.

b The alphanumeric locating dot was the ASCII peri: It was difficult to see.

c Once the sequence of picks with the light pen to initiate the symbol and locate the start of the line was completed, the creation of line-type graphics was easy. With the starting point specified, succeeding inflection points and the end point of the line were indicated by the trackball-controlled cursor. As the cursor was moved to each point, a line was automatically displayed from the last point to the current location of the cursor. This gave a dynamic "rubber band" effect and allowed the operator to see the length and angle of the desired line segment before he fixed the inflection or end point. This feature was very useful.

d Circles of varying size were also easy to create once the symbol pick sequence was initiated and the center of the circle was specified. The trackball was used to move the cursor inward or outward from the center. The movement inward or outward increased or decreased the radius of the circle. The size of the displayed circle changed continuously as the cursor was moved. This feature was very useful. The system did not have an ellipse generator.

3 Photochromic.

a The procedures used by the photochromic system met, except for certain line-type graphics, the intent of this requirement. The procedures for the creation of alphanumerics, military unit symbols, individual graphic items, and solid lines used a minimum of steps. They were easy to learn and their use was straightforward. The procedures required pressing pushbuttons in a specified sequence. Error made by the operator in the creation of alphanumeric and military unit symbols were minimal because the system led the operator through the procedure. This was accomplished by automatic positioning of the cursor at the part of the symbol that the operator needed to create next. The functional grouping of the pushbuttons assisted the operator in locating the appropriate pushbuttons.

b The alphanumeric locating dot was a coordinating point symbol. This dot was larger than the ASCII period and was satisfactory in designating the location of the alphanumeric.

c Line-type graphics, with the exception of solid lines, were very difficult to create. The two line-type graphics which the system was capable of displaying were trenches and lines of contact (defensive frontline traces). To create these symbols, the operator had to repeatedly input individual elements between the start, inflection, and end points of the line. This was a tedious process which should have been automatically accomplished by the system after the start, inflection, and end points of the line were specified.

d The system did not have a circle or ellipse generator.

e The alphanumeric character pushbuttons on the DCU keyboard were not positioned in the exact standard typewriter layout. This was not disconcerting to an operator who had no typing experience, but an operator who had extensive typing experience would require adjustment to the layout.

f The system included a feature with which alphanumeric, military unit, and line-type graphic symbols could be rotated in 15° increments up to plus or minus 90° from their normal position. No firm requirement for this feature was identified. The feature was used in creating trench lines and defensive frontline traces, but it would be unnecessary if the procedure recommended in the requirement for the creation of line-type graphics were employed.

(38) Evaluation for requirement number 38.

(a) Requirement 38. The procedure for correcting data items in a display should be similar to that listed in the following subparagraphs:

1 Press the CORRECT data item pushbutton.

2 Point out the item to be corrected. (Visual feedback as to which symbol was selected should occur.)

3 Correct the symbol by using the procedure discussed in the following subparagraphs for that type item. If a color change is all the operator desires, he should only have to press the appropriate color pushbutton.

a Alphanumerics. Alphanumeric correction must allow for advancing or backspacing to any character in the data item. A marker must indicate which character will be changed if an ASCII key is pressed.

b Military unit symbols. The procedure for military unit symbol correction must also use a marker to indicate to the operator which portion of the symbol the system is ready to change. The marker under operator control either advances or backspaces through the parts which make up the data item (flag, branch, identifications, echelon). This allows him to change any or all parts of the item.

c Graphics. Line segment graphic item correction is much like the correction of alphanumerics and military unit symbols as a marker indicates to the operator which inflection point the system is ready to change. The graphic type (i.e., solid line, trenches) is also subject to change. Correction of circle radii or ellipse major and minor axes requires indicating the new radius or axis by pointing at its location on the screen. Correction of individual graphic symbols (i.e., mines, control points) should only require pressing the pushbutton for the desired symbol.

4 If the operator desires to start over again he should only have to press an ABORT pushbutton.

5 Press the COMPLETE pushbutton. The console should return to the operational state which existed prior to pressing CORRECT.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	Met	No
No (AC)		

(c) Discussion.

1 Scribe. The operator could not directly correct displayed data items. Symbol correction required deletion of the symbol and creation of the correct symbol.

2 CRT. Each displayed item was made up of several parts called "strings." Three picks with the light pen were required to initiate the procedure, identify the symbol to be corrected, and position the cursor at the first string. The cursor could be moved forward or backward through strings of the symbol. Correction of the incorrect string was performed by creating a new string which automatically replaced the old string.

3 Photochromic. The procedure for correcting a military unit symbol met the requirement, but the procedure for correcting an alphanumeric symbol and a line-type graphic symbol (except for a solid line) did not. Correction of an alphanumeric symbol required that the entire symbol be deleted and the correct symbol be created. Line-type graphics (defensive frontline traces and trenches) required deletion of each individual element of the line. The correct line was then created by positioning and inputting each individual element of the new line. This was a tedious process and placed an unnecessary burden on the operator. Military unit symbols were easily corrected as the procedure allowed the operator to position a cursor at the part of the symbol that required correction.

(39) Evaluation for requirement number 39.

(a) Requirement 39. The procedure for moving a data item applies to all data types except line segment graphics and should be similar to the procedure listed below:

- 1 Press the MOVE data item pushbutton.
- 2 Point out the item to be moved. (Visual feedback as to which item was selected should occur.)
- 3 Point to the desired new location on the screen or type in the coordinate location. (There should be visual feedback of the coordinate being typed.)
- 4 If the operator desires to start over at any point he should only have to press the ABORT pushbutton.
- 5 Press the COMPLETE pushbutton. The console should return to the operational state which existed prior to pressing MOVE.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met (EC)	Met	No
Met (AC)		

(c) Discussion.

1 Scribe. An alphanumeric command was used to move a symbol. The command was relatively easy to learn and use. The letter "M" was typed to indicate a move. Then the operator had the option of selecting the symbol either by UTM coordinate entry or by the cursor. The new location of the symbol could also be specified by UTM coordinate entry or by the cursor. The visual feedback of moved symbols was marginally acceptable. A move was indicated by a straight line drawn from the symbol's old location to its new location. However, when the display was regenerated, the line was removed; and the symbol appeared at its new location. This affected the operator's perspective, especially if several moves were made before the display was regenerated.

2 CRT. The procedure for moving a symbol was easy to use. Two picks with the light pen were required to initiate the command and indicate the symbol to be moved. The symbol could be positioned at its new location by movement of the cursor (light pen or trackball controlled) or by typing in the UTM coordinates of the location.

3 Photochromic. The operator could not directly move a symbol. A move could be indicated by drawing a line from the old to the new location or by deleting the symbol and creating it at the new location.

(40) Evaluation for requirement number 40.

(a) Requirement 40. The procedure for decluttering (offsetting) a data item applies to all data types except graphics and should be similar to the procedure listed below:

1 Press the DECLUTTER data item pushbutton.

2 Point out the item to be decluttered. (Visual feedback as to which item was selected should occur.)

3 Move the item to the desired new location. The item must appear to move with the pointer. This helps the operator to position it in the least cluttered area of the screen. A line will appear between the item's offset location and its true location.

4 If the operator decides not to declutter the item after all, he should only have to press the ABORT pushbutton.

5 Press the COMPLETE pushbutton. The DECLUTTER pushbutton should remain activated until the operator turns it off.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	Met	
No (AC)		No

(c) Discussion.

1 Scribe. An alphanumeric command was used to declutter a symbol. The command was as easy to learn and use as the command for moving a symbol. The letter "D" was typed to indicate a declutter. The options available for indicating the symbol to be decluttered as well as the decluttered position were the same as those for the move command. The visual feedback was unacceptable. A new symbol was drawn at the location indicated by the operator. A line was then drawn from the symbol's offset location to its true location. However, the original symbol remained displayed because of the storage tube display technique used. This required the operator to regenerate the display to show only the decluttered symbol. Regeneration of a typical display required approximately 40 seconds. Another shortcoming of the declutter function was that declutter lines were not directly attached to military unit symbols. This caused comprehension of the display to be difficult when it contained a number of decluttered symbols.

2 CRT. The procedure for decluttering a symbol was easy to use. Two picks with the light pen were required to initiate the command and indicate the symbol to be decluttered. The symbol was positioned at its offset location by movement of the cursor. Visual feedback was continuous. This allowed the operator to view the symbol and its declutter line at different offset locations before selecting the final declutter position of the symbol.

3 Photochromic. The operator could not directly declutter a symbol. Declutter of a symbol required that the symbol first be deleted, then re-created with an offset line drawn from the declutter location to the true location.

(41) Evaluation for requirement number 41.

(a) Requirement 41. The procedure for deleting a data item applies to all data types and should be similar to that listed below:

- I Press the DELETE data item pushbutton.

2 Point out the item or items to be deleted. More than one item can be deleted at a time. As each item is pointed to, it must disappear from the display.

3 If the operator decides not to delete the items selected, he should have the option of pressing the ABORT pushbutton, thereby restoring all the temporarily deleted symbols.

4 Press the COMPLETE pushbutton. The console should return to the operational state which existed prior to pressing DELETE.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	Met	No
No (AC)		

(c) Discussion.

1 Scribe. An alphanumeric command was used to delete a symbol. The command was relatively easy to learn and use. The letter "E" was typed to indicate a deletion. Then the operator had the option of selecting the symbol either by UTM coordinate entry or by the cursor. The visual feedback means was unacceptable. The deleted symbol remained on the display due to the persistent phosphor used in the storage tube display technique. Verification of a deletion required the operator to initiate a display regeneration. The regeneration of a typical display required approximately 40 seconds.

2 CRT. The procedure for deleting a symbol was easy to use. Two picks with the light pen initiated the command and deleted the symbol from the display. Depending on the function picked from the "modify" menu, the operator had the option of deleting the item from both the display and the data base or from the display only. This option was very useful for temporarily clearing the display of unwanted symbols so that other symbols could more easily be seen.

3 Photochromic. The procedure for deleting alphanumeric, military unit, and individual graphic symbols met the requirement. Deletion of a symbol required that the symbol to be deleted be indicated (with the joystick or by typing the UTM coordinates) and that the DELETE pushbutton be pressed. The procedure for deleting trenches and defensive frontline traces was unacceptable. The operator was required to delete each individual element of the line. This was a tedious process and was an unnecessary burden on the operator. The cursor jumped to the lower left corner each time any symbol was deleted. This was not a desirable feature.

(42) Evaluation for requirement number 42.

(a) Requirement 42. The console must allow the user to create at least 10 branch duty symbols. Each created symbol must be associated with a particular pushbutton on the console. The pushbuttons are used in exactly the same manner as the permanent branch duty symbol pushbuttons in the creation and correction of military unit symbols. The procedure for creating additional branch duty symbols is listed below:

1 Press the CREATE SYMBOL pushbutton. This should cause an enlarged military unit flag (rectangle) to appear on the console screen.

2 By using the create graphic symbol procedure, (see requirement 37 above) create the desired branch symbol as a series of short line segments inside the flag.

3 Press the pushbutton the branch symbol is to be associated with. The pushbutton should allow the operator to affix a copy of the symbol to it. If a symbol has been previously assigned to this pushbutton, this step replaces it with the newly created branch duty symbol.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met (EC)	Met	No
Met (AC)		

(c) Discussion.

1 Scribe.

a The system marginally met this requirement. Each created branch symbol was identified by a number and was made a part of the special symbol library. While the procedure for creating the symbol was easy and straightforward, the means of using the created symbol did not meet the intent of the requirement, since it could not be used in exactly the same way as the branch symbols in the permanent symbol library.

b The symbol was created and was input to the special symbol library through the map overlay input device. An enlarged format of the military symbol rectangle was positioned on the map overlay input device, and the branch symbol to be created was sketched to the appropriate dimensions inside the rectangle. The map overlay input device was then used to input the symbol as a series of short line segments. The number of special symbols that could be created was dependent upon the number of line segments that the symbol required. A maximum of 26 symbols of varying complexity were created during the experimentation.

c Use of the created symbol required two alphanumeric commands. The fTrst command created the required military unit symbol except for the branch symbol. A second command was required to add the created branch symbol in its correct location within the rectangle.

d Deletion of the created symbol from the library required typing "ES" and the special symbol number.

2 CRT.

a The user could create nine special symbols. The created branch symbols were made part of the symbol menu and were used in exactly the same way as the permanent branch symbols. However, these symbols could not be reproduced on the map overlay output device.

b The symbol was created as a series of short line segments inside a rectangle format which was eight squares wide by six squares high. The rectangle was displayed on the console screen, and the small squares were used by the operator to position the short line segments starting from the lower left corner of the rectangle. Each line segment was specified by a typed alphanumeric command that gave the type (solid line or blank), the length, and the angle of the segment (1° to 360° in $22 \frac{1}{2}^\circ$ increments). The operator could call for the display of partially created symbols at any time. Correction of line segments was possible by backspacing until the segment to be corrected was reached, then inputting the correct segments.

c Deletion of the created symbol from the menu required picking the DELETE SYMBOL function with the light pen and pointing (with the light pen) to the symbol to be deleted.

3 Photochromic.

a The user could create nine special symbols. Each symbol was identified by a number. The procedure for creating the symbol was easy and straightforward, but the means of using the symbol did not meet the intent of this requirement, since the created symbol could not be used in the same way as the branch symbols in the permanent symbol library.

b To create a branch symbol, a military unit rectangle was first displayed. The symbol was then created as a series of short line segments inside the rectangle. The quality of the created symbol was marginal because of the small size of the rectangle. An enlarged rectangle for use in creating branch symbols would have been ideal.

c Use of the created symbol required that the military unit symbol, except for the branch symbol, be created first. The created branch symbol was then positioned inside the rectangle by using the joystick.

d Deletion of the symbol from the library required that the DELETE pushbutton be pressed and the symbol number be typed.

(43) Evaluation for requirement number 43.

(a) Requirement 43. The console must allow the user to create at least five individual graphic symbols. As is the case for branch duty symbols, each created graphic symbol must be associated with a particular pushbutton on the console. The pushbuttons are used in exactly the same manner as the permanent individual graphic symbol pushbuttons in the creation and correction of graphic symbols. The procedure for the creation of additional graphic symbols is the same as the procedure for military unit branch symbol creation (see requirement 42 above). When the operator presses the CREATE SYMBOL pushbutton, the enlarged rectangular format used in the creation of military unit branch duty symbols provides the operator with a ready frame of reference. Since the operator knows that the enlarged format reduces to the size of a military unit symbol rectangle on a display, he can create the desired graphic symbol to the appropriate size inside the format.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met (EC)	Met	Met
Met (AC)		

(c) Discussion.

1 Scribe.

a Individual graphic symbols could be created and made part of the special symbol library. The procedure for the addition and deletion of these symbols was identical to that described in requirement 42 for branch symbols.

b It was relatively easy to display the created symbol. An alphanumeric command was typed which specified the special symbol number and the location (UTM coordinate entry or cursor positioning) at which the symbol was to be displayed.

2 CRT. Individual graphic symbols could be created and made a part of the symbol menu. The procedure for creating and deleting symbols was identical to that described in requirement 42 above for branch symbols.

3 Photochromic. Individual graphic symbols could be created and made a part of the symbol library. The procedure for creation and deletion of the symbols was identical to that described in requirement 42 above for branch symbols.

(44) Evaluation for requirement number 44.

(a) Requirement 44. The console must allow for the creation of at least two line-type graphic symbols. The created symbol must be associated with a particular pushbutton on the console. The pushbuttons are used in exactly the same manner as the permanent line-type graphic symbol pushbuttons. The procedure for the creation of line-type graphic symbols is the same as that used for the creation of military unit symbols and individual graphic symbols (see requirements 42 and 43 above). By using the enlarged rectangular format as the frame of reference, the operator can create a repeatable element of the graphic line-type symbol of the appropriate size inside the format.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. None of the three systems had the capability for creating repeatable segments of line-type graphics which could automatically be displayed between two specified points. This requirement was identified as a result of the experimentation.

(45) Evaluation for requirement number 45.

(a) Requirement 45.

1 Ideally, background map display should require the operator to only specify the level of detail and the area of coverage desired. Registration with the dynamic symbology should be automatic. If a particular background is to be frequently displayed, the operator must have the option of giving it an identification label which will allow its recall without the operator having to respecify the level of detail and area of coverage. The currently selected categories of dynamic symbology in a newly selected area of coverage must appear automatically.

2 The procedure for obtaining a desired map background should be similar to that listed below:

a Press the SELECT MAP pushbutton.

b Use ASCII keys to type in the desired map identification label if the map is one that has been identified previously.

c If the desired map has not been identified, select the desired detail by pressing the appropriate pushbuttons (i.e., ROADS, GRIDS, RIVERS, TOWNS). Type in the coordinate (grid zone designation and four or six digits) for the extreme lower left and upper right corners of the desired area of coverage.

d Press the SELECT MAP pushbutton again. This causes the desired map to be displayed and the pushbutton to be turned off. (The map must be displayed in 15 seconds or less.)

3 The operator should be able to add or subtract map detail. This should only require that he press the appropriate map detail pushbutton (i.e., ROADS, RIVERS, GRIDS, TOWNS). Detail will either be added or subtracted depending on whether or not it is currently displayed.

4 If at any time the operator wants to give a label identification to the map currently displayed so that it can be recalled, he should be able to do so by pressing the ADD MAP ID pushbutton and then typing the desired label on the ASCII keyboard. Map identification labels should be console peculiar (i.e., each console will have its own set of labels). Other console operators will be able to retrieve a map identified on a different console by using the appropriate prefix for that console.

5 The label of the map currently displayed should appear at a particular location on the display screen. If that particular combination of detail and area of coverage has not been labeled, no label should appear. A list of labels currently being used to identify maps on that console should be available upon request of the operator. Maps may be deleted from this list by pressing the DELETE MAP ID pushbutton and pointing to the label of the map to be deleted.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. None of the three systems had the capability to provide the ideal means of attaining background coverage. This requirement was identified as a result of the experimentation.

(46) Evaluation for requirement number 46.

(a) Requirement 46.

I If the ideal background map display procedure described in requirement 45 is not possible, discrete background maps, although not

as flexible, offer an alternate approach. If the user is given an infinite number of on-line discrete background maps, he can approach the flexibility of the ideal map described above. However, an infinite number of on-line maps that have varying areas of coverage and different combinations of detail is not realistic. Realizing this, the following considerations are provided to assist in the specification of systems that use discrete map background presentation.

2 Each display system must have a number of discrete maps on line. Each map in the set must be available within 15 seconds. Initial registration and cataloging of a map must only require that the operator point out two diagonally located grid intersections or two known (diagonally located) points and type in their coordinates (grid zone designator and 4, 6, ~, 8 digits). The operator must assign an identification label to the map so that it can be easily recalled. This label must be visible whenever the map is displayed. Once the map is registered, it must not require reregistration upon recall.

3 Background orientation or scale must be immaterial when registering a map. There must be no requirement that the map be exactly vertical or centered or that it have a particular magnification factor. In addition, a means for easily changing on-line backgrounds either singly or as a set must be provided.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	No	
NA (AC)		No

(c) Discussion.

1 The CRT and photochromic consoles could provide up to 80 discrete addressable slides of map background areas. The average access time to a slide was 5 seconds. Each background was identified by a number (1 through 80). When a background was displayed, the CRT console displayed the map number at the top edge of the background. The photochromic system did not display the background number with the background; however, the slide number currently selected was indicated by a 2-digit dial located on the console.

2 New map backgrounds could not be easily registered on either system. The registration procedures were inflexible and placed an unnecessary burden on the user. As a result of assumptions made in the design of the software, the user was forced to prepare backgrounds that met stringent technical requirements. This made it difficult to change the discrete map areas available on line and was the major drawback of both systems' map area of coverage capability.

3 Comments on the map registration procedures for both the CRT and photochromic consoles are the same as those for requirement 27.

(47) Evaluation for requirement number 47.

(a) Requirement 47.

1 The console must be able to store and display data items by category. When a new data item is added to the system's data base, the system must allow the user to specify which category or categories the data item is to be stored and displayed under. It must be possible to assign a data item to more than one category and to change the category or categories of any displayed data item. The number of categories required is approximately 30.

2 Data items associated with a particular echelon (e.g., hostile and friendly units) may be required to be displayed by echelon for a selected category. For example, a user may wish to display the category containing friendly unit locations but want to see only those units of brigade size or larger. A set of pushbuttons to specify the desired echelons should be provided for this purpose.

3 It is desirable to allow the user the option of specifying the time frame for categories which he selects. An example of the use of this option is the display of reported vehicular movement from (date time group) to (date time group). If the option is not exercised, the system displays all data for the selected category and echelon. The time frame applies to all categories selected for display.

4 The procedures listed below are provided as a guide to data category selection and category change. Initial assignment of a data item to a category is discussed in the procedure for data item creation (requirement 37 above) and the requirement for TOS message receipt (requirement 49 below).

a Category selection.

(1) Press the desired echelon pushbuttons for the categories to be displayed. The echelon selection applies to all displayed categories which have echelon associated data items.

(2) Press the desired category pushbuttons. This causes the display of data items in the desired categories for the specified echelon(s). Pressing a category pushbutton which is lit disengages the pushbutton, turns the light off, and causes all data items belonging to that category to be removed from the display.

b Category change.

- (1) Press the CHANGE CATEGORY pushbutton. This causes all category pushbuttons which are lit to be turned off.
- (2) Press the desired category pushbuttons.
- (3) Point to the data item (or data items if more than one data item is to be stored in the new categories) on the display. (Visual feedback to indicate the selected symbols should occur.)
- (4) Press the CHANGE CATEGORY pushbutton. This assigns the selected data items to the new categories. The light on this pushbutton turns off, and the previously lit category pushbuttons turn on.
- (5) The user may press the ABORT pushbutton at any time during the procedure. This returns the display to the state it was in before the procedure was initiated.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	No	NA
No (AC)		

(c) Discussion.

I Scribe.

a Data items were stored by data type. (The items belonging to a "data type" were equivalent to a "category" called for in this requirement.) A user-created data item was assigned a data type code by the operator when the item was created. Data items transmitted from DEVTOS were assigned predetermined data type codes and were stored under those data types when received by the system.

b Ten data types were available. Five types were used for friendly data items, and the other five were used for hostile data items. This was done because hostile and friendly data on the group display were scribed on separate projectors. Consequently, an equal number of data types were assigned to each projector.

c Category selection was established by defining the displays. The user could define up to 16 displays. When defining a display, the user specified the color filters to be used by the five projectors on the group display, the slide positions for the two scribing and the two reference projectors, and the data types contained in the display. Thus, each display contained a combination of data types for a specified area of map coverage.

d When a data item was created by the operator, the alphanumeric command which created the item specified whether it was a friendly or hostile item and assigned a data type to the item. The data type determined which display(s) the item was a member of. A data item was assigned to more than one display if the item's data type was defined in more than one display.

e The user could not change an item's data type without deleting the item and re-creating the item in the desired data type. However, the displays could be redefined to include different combinations of data types.

f There was no provision for restricting the echelon of military unit symbols on displays and no provision for specifying a display by time frame.

g The procedure for category assignment and display was cumbersome and did not meet the degree of flexibility called for in the requirement. Additionally, the number of categories was insufficient.

2 CRT.

a Each user-created data item was stored in a selected category when the item was created. Data items transmitted from DEVTOS were assigned predetermined categories and were stored in the appropriate category when received by the system.

b A data item was assigned to only one category. The operator was able to change the category of a data item with the light pen. Fourteen categories were available, and a data item could be stored in any one of the fourteen. There was no provision for category display by time frame.

c The categories were listed in a menu which was displayed on the left side of the console screen when the operator pressed the CATEGORY SELECT pushbutton. The operator selected the desired categories from the displayed menu with the light pen. Any combination of categories up to and including the 14 listed in the menu could be selected. The category select menu also included a listing of echelons from company to Army. By picking an echelon, the operator restricted the size of displayed military unit symbols to that echelon and higher. When the category select menu was displayed, categories which had been or were selected for the displayed area of coverage blinked on and off to indicate which categories defined the display. The blinking tended to be distracting. The selected categories could have been better indicated by pointers.

d When the displayed map area of coverage was changed, data items (in the currently selected categories) which were located in the new map area of coverage were automatically displayed. The only exception was multiple point items which did not have all points in the new area of coverage. (See requirement 14.)

e The procedure for category assignment, selection, and change approached the flexibility and ease of use intended in the requirement. However, the inability to assign a data item to more than one category was unsatisfactory and the number of categories was insufficient.

3 Photochromic. The inability to assign data items to categories and to display data items by categories was a serious shortcoming of the system.

(48) Evaluation for requirement number 48.

(a) Requirement 48.

1 A means for storing display scenes is required. The system must also have the capability to re-store these modified display scenes. The procedure for storing display scenes should be similar to that listed below:

a Press the STORE HISTORY pushbutton.

b Type a brief description of the scene that was stored. Visual feedback of what is typed should appear on the lower edge of the scene.

c The system adds this scene description to its current listing of stored scenes for that particular console.

d Press the STORE HISTORY pushbutton again. This completes the storage procedure and the pushbutton light goes off.

2 The procedure for the recall of stored display scenes should be similar to that listed below:

a Press the RECALL HISTORY pushbutton. A list of the currently stored scene descriptions for that console is displayed. (If the console operator wants a listing of another console's stored scenes, he types that console's prefix.)

b Point to the scene description desired. The selected scene must appear within 15 seconds. Deletion of scenes in the list should only require pressing the DELETE pushbutton and pointing to the appropriate description.

c Return to the display shown prior to history recall is accomplished by repushing the on-off RECALL HISTORY pushbutton.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	No	NA
No (AC)		

(c) Discussion.

1 The scribe and CRT systems had the ability to store and recall displayed scenes, but the capability did not fully meet the requirement. Neither system had the ability to list the currently stored scenes. As a result, the operator had to write the scene storage data and its description on a history log for future reference. The procedures for storing a displayed scene were easy to use. The scribe system required a two-character alphanumeric command followed by the display number. The CRT system required that the STORE HISTORY pushbutton be pressed.

2 Both systems stored display scenes on magnetic tape. The recall procedure required the operator to specify the history storage data (the time recorded by the system when the scene was stored). Since the scenes were recorded sequentially on the magnetic tape, the time required to recall a scene depended upon the location of the scene on the tape at the time of recall. If the tape position and the scene position coincided, recall was completed within 10 seconds. However, if the worst case occurred (i.e., the tape was positioned at the last record on the end of the tape and the scene desired was the next to last record), the recall time was much longer because the tape was wound again and the search for the desired record began from the start of the tape. The scribe system's tape can be used as an example. Its worst case time was approximately 8 minutes. The time was based on the tape length of 2,400 feet, a rewind speed of 24 feet per second, and a forward (search) speed of 7 1/2 inches per second. The time could be reduced if a shorter tape length was used. The use of magnetic tape as a means of storing displays did not provide the recall speed specified by the requirement.

(49) Evaluation for requirement number 49.

(a) Requirement 49.

1 Each console must have the ability to send data items to, and receive data items from, TOS. Update of the TOS data base should only require that the operator press the TOS DATA pushbutton and point to the data item(s) selected. The data items, along with their associated free text, are sent to TOS when the TOS SEND pushbutton is pressed.

2 TOS data is either received as a result of a standing request or information (SRI) or a query from a particular console. The SRI or query establishes the console data category or categories that incoming data items are assigned to. When a data item is received, it is automatically displayed and highlighted if it is in the area of map coverage displayed. It is displayed and highlighted regardless of the currently selected categories. The item continues to be highlighted until the operator points to it and presses an ACCEPT, SAVE, or REJECT pushbutton to indicate that he sees the item. The ACCEPT pushbutton adds the data item to the designated display categories. The SAVE pushbutton adds the

item to a special TOS save category. Data items in the TOS save category can be transferred to display categories at any time. The REJECT pushbutton deletes the item. Blinking is an acceptable means for automatic highlighting although any other means that is equally as attention getting is acceptable. If a data item received from TOS is not in the currently displayed area of map coverage, it appears and is highlighted the first time the operator selects an area of coverage that includes the item's location. Military unit symbols that have branch duty symbols that are not contained in the permanent symbol generator must appear with the first four letters of the branch duty inside the rectangle.

3 When a TOS data item is an update to data already in the system, pressing the ACCEPT pushbutton causes automatic replacement of the previous information. An example is the automatic update of a particular unit's location or the relocation of a particular boundary.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	No	NA
No (AC)		

(c) Discussion.

1 General. The scribe and CRT design specifications did not require that the systems be able to transmit data to an outside ADP source. Data transmitted to the systems was established by a standing request for information (SRI) or by query. The SRI or the query was not initiated at the system's console, but from a DEVTOS message input-output device (MIOD) that was co-located with the system. DEVTOS data items were assigned predetermined categories and were stored in these categories when received by the systems.

2 Scribe.

a Each incoming DEVTOS data item in the currently selected area of map coverage was displayed if it was one of the data types defined for the display. Highlighting of the new item was accomplished by moving the cursor to the item's location. That means of highlighting was unsatisfactory. The cursor was the same color as the dynamic symbology; it was a small "o" and frequently was hard to locate in the display without moving it so it could be seen. At the time of receipt and before the DEVTOS item became part of the system's data base, the operator could accept or reject the item by pressing an ACCEPT or a REJECT pushbutton.

b Incoming DEVTOS data interrupted any ongoing data manipulation at the console. This was unacceptable to the operator since it effectively made the console useless until the data transmission and acceptance (or rejection) was complete. The acceptable alternative would have been to allow the operator to function normally at the console while the incoming data was being displayed.

c DEVTOS data items that were not in the selected area of coverage were displayed the first time an area that included the item's location was displayed. This was subject to the condition that the display for that area of coverage included the item's data type in its initial definition.

d A DEVTOS data item which was an update to a data item currently in the data base did not automatically replace the old item in the data base. Thus, both the new and old DEVTOS data items were displayed. This caused an unnecessary burden on the operator, as he had to manually delete the old items. In many instances it was not easy to determine which was the old item and which was the replacement item.

3 CRT.

a Each DEVTOS data item located in the currently selected area of map coverage was displayed upon receipt if it was in one of the categories selected for display. The item was highlighted by causing it to blink. The blinking stopped when the operator regenerated the display. Incoming DEVTOS data did not interrupt ongoing data manipulation.

b Data items received from DEVTOS were automatically added to the system's data base. If the user decided that the item was of little significance and was unnecessary, he had to delete the item.

c DEVTOS data items that were not in the selected area of coverage were displayed and highlighted the first time an area that included the item's location was displayed provided that the item's category was one of those selected for display.

d A DEVTOS data item which was an update to a data item currently in the data base automatically replaced the old item in the data base. For example, a unit's boundary or defensive frontline trace was automatically updated. However, data items which were only partially specified were also automatically replaced. This was unsatisfactory. For example, a data item which was transmitted from DEVTOS and displayed as an unknown tank battalion was replaced whenever another data item specified as an unknown tank battalion was received. This was done even though the new data item was not the same unit and was located at an entirely different part of the map area. It was corrected so that only those data items which were completely specified (e.g., a military unit which included the left and right identification, the size, and the branch duty symbol) were replaced.

(50) Evaluation for requirement number 50.

(a) Requirement 50. The transfer of entire displays from one console to another must be provided for. This can be between consoles within an automated display system or between a console in one system

and a console located in another system at another echelon. The transfer will generally be in answer to a verbal request for specific information. The procedure should only require that the operator obtain the desired display in the normal manner, press a SEND DISPLAY pushbutton, and type an identification for the console which is to receive the display.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. This requirement was identified as a result of the experimentation.

(51) Evaluation for requirement number 51.

(a) Requirement 51. Transmission of alphanumeric data from one display system to another display system's printer should be possible from the interactive graphic display console. The data is stored by category and is transmitted one category at a time. The procedure should only involve displaying the appropriate category, pressing a SEND ALPHANUMERIC pushbutton, and typing the prefix of the printer where output is desired.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. This requirement was identified as a result of the experimentation.

(52) Evaluation for requirement number 52.

(a) Requirement 52.

1 An automated display system must have the ability to provide additional data on any display data item upon user request. It must also provide the user with the ability to add his own free text remarks.

2 To obtain additional data on a displayed data item or to add a comment on the item, a procedure similar to that listed below should be used:

- a Press the EXTRA DATA pushbutton on the console.

b Point to the desired data item. This causes the display of a three-part format. The display of this format must not replace the graphic display. The format can be displayed on the same screen with the graphic display or on a separate, but nearby, alphanumeric display screen.

(1) The first part of the format is automatically completed by the system and includes, as a minimum, the grid coordinate(s) of the data item. Other data which can be included in this part of the format are the date time group, the originator, and the reliability of the data.

(2) The second part of the format is provided for the entry of optional free text remarks by the originator of the data item. If the data item is transmitted from an outside source such as TOS, the sender's remarks (if any) are entered here. If the data item is originated by the display system user, his remarks (if any) are entered here.

(3) The third part of the format is provided for optional free text remarks by the recipient of the data item. A data item transmitted from an outside source has this part of the format for the display system user's comments (if any).

c Type free text comments (if any) in the second part (originator) or third part (recipient) of the format.

d Press the EXTRA DATA pushbutton. This turns the pushbutton light off and deletes the extra data format from the display.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. This requirement was identified as a result of the experimentation.

(53) Evaluation for requirement number 53.

(a) Requirement 53.

I A number of control switches or knobs are required on the interactive graphic display console. The controls must be on the console. The console operator should not have to leave his position in order to reach them. The controls listed below must be included:

a Dynamic symbology brightness control knob. Turning the knob one way or the other increases or decreases the *overall* brightness of displayed dynamic symbology within the range from maximum brightness to the dynamic symbology being completely faded from the screen.

b Map background brightness control knob. Turning the knob one way or the other increases or decreases the *overall* brightness of the displayed map background. The brightness is controllable from maximum brightness to the map background being completely faded from the screen.

c Restart-reset pushbutton. This pushbutton is used when operator or system error causes the processor to halt. Pressing the pushbutton causes a reload of the display program if necessary and/or resetting of the program parameters to what they were before the halt. The system must be operational within 15 seconds after this pushbutton is pressed. However, return to full operational status within 2 or 3 seconds is highly desirable.

2 The controls listed below should be included on the console:

a Color brightness control knob(s). One knob is provided for each color of dynamic symbology. The knob has the same function and range as the dynamic symbology brightness control knob except that it controls the brightness of an individual color.

b Map feature brightness control knob(s). These controls are necessary if the ideal map background display is practical. One knob is required for each color used to identify a specific map feature (e.g., roads, vegetation, rivers). The function and range of the knob is the same as the map background brightness control knob except that it controls the brightness of an individual map feature color.

c Symbol size control knob. Turning the knob one way or the other varies (within a specified range) the size of all data items except line-type graphic items, circles, and ellipses. When the control is used, all parts of the data item (e.g., the rectangle, the branch duty symbol, the left identification, the right identification, and the echelon) are either enlarged or reduced proportionally. Changing the size of the symbol must not change the symbol's apparent map location.

3 Other controls may be required, depending upon the display technique used. For example, individual dynamic symbology and map background focus knobs may be necessary.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photchromic</u>
No (EC)	No	No
No (AC)		

(c) Discussion.

1 Scribe.

a A control knob on the consoles was used to adjust the brightness of dynamic symbology. The consoles had no capability for displaying map backgrounds; therefore, they did not require a background brightness control. A separate control knob was used to focus the dynamic symbology.

b There was no restart-reset control on the consoles. The display program was reloaded from the magnetic tape unit. This took approximately 5 minutes.

c Symbol size change for the entire display was accomplished by typing an alphanumeric command for the symbol size desired rather than by a control knob.

2 CRT.

a A control knob on the console was used to vary the overall brightness of the dynamic symbology. No control was available for varying the individual color brightness. A separate knob was used to focus both colors of dynamic symbology.

b There was no restart-reset control on the console. However, resetting or restarting was initiated at the processor and met the time specified by this requirement. The system's operating system and display control routines were on an on-line magnetic disk unit.

c There was no control for adjusting the brightness of the displayed map background. Size change of individual alphanumeric, individual graphic, and military unit symbols was accomplished by the light pen rather than by a control knob. Symbol size change for the entire display was not controllable.

3 Photochromic.

a Separate control knobs on the console were used to adjust the brightness of the dynamic symbology and the displayed map background. Separate knobs were also used to focus the dynamic symbology and the map background. Other controls included a knob to adjust the tilt of the displayed map background image and knobs to adjust the vertical and horizontal dimension of the electronically generated border to match the displayed map image size.

b There was no restart-reset control on the DEEM or on the DCU. The display program was reloaded from a high speed paper tape reader. This took approximately 5 minutes. When the paper tape reader was inoperable, the reload was performed by the teletype. This took approximately 45 minutes and was totally unacceptable.

c The symbol size on the system was not variable.

(54) Evaluation for requirement number 54.

(a) Requirement 54.

1 The display system must notify the interactive graphic display console operator when he performs a step in a procedure incorrectly. The notification means must be positively attention getting, must be rapid, and must specify exactly what was done wrong. An audio alert such as a bell or buzzer should sound whenever an error occurs. Incorrect attempts to recover from the error cause additional audio alerts. The error message display must not delete the current situation display. The error message continues to be displayed until the operator performs the correct step in the procedure or until he presses the ABORT pushbutton at which time the error message is deleted and the display returns to the state it was in before the series of commands was initiated.

2 The error message must tell the operator exactly what he did wrong. The use of error codes which require the operator to look up the code to determine the error is not user oriented and is not acceptable. Ideally, the error message should state what step of the procedure was performed incorrectly. For example, using the procedure outlined for the creation of military symbols, an error message might read: "Last pushbutton depressed was not branch duty."

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No (EC)	No	No
No (AC)		

(c) Discussion.

1 Scribe. The operator was notified of an error by an "E" displayed on the console. Most errors occurred during the typing of an alphanumeric procedure command. Recovery from the error required the operator to retype the command or reinitiate the procedure.

2 CRT. The operator was notified of an error by the ERROR MESSAGE pushbutton being lit and a blinking error code on the console screen. The error code consisted of four digits. Unless the operator was familiar with the displayed code, he was required to consult a table to determine what the code meant. To recover from the error, the operator pressed the ERROR MESSAGE pushbutton to turn the light off. He then continued with the correct step in the procedure or reinitiated the procedure.

3 Photochromic. The operator was notified when an error in the procedure occurred by the lack of audio feedback when he pressed the pushbuttons on the DCU. Also, the system would not respond. Recovery from an error required reinitialization of the display processor and in some cases a reload of the display program.

(55) Evaluation for requirement number 55.

(a) Requirement 55. The principal users (i.e., G2, G3) should not be deprived access to a console for periods longer than 15 minutes.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA (EC)	NA	NA
NA (AC)		

(c) Discussion. This requirement was identified as a result of the experimentation.

2-10. Group Display Output Device. A description of the device in each of the three candidate systems which performed functions corresponding to the requirements stated for the group display output device follows:

a. Scribe - Vigicon large screen display.

(1) The Vigicon large screen display used a rear screen projection technique to project a 5-foot by 5-foot color display onto a rigid screen that was located 10 feet from the projectors. The display was a composite image projected from five individual projectors (two scribing, two reference, and one spotting). The projectors used incandescent 750-watt lamps as a light source. The color of each projector's output was selectable by the selection of computer-controlled filters (blue, green, yellow, orange, red, and clear). The light intensity of each projector was controlled by manual aperture settings.

(2) The two scribing projectors generated the dynamic display symbology by means of an X-Y plotting mechanism. The mechanism used a transparent stylus plate, located in the optical path, to scribe symbology onto metal coated glass slides (40 slides per projector). The effective scribing area was 1 inch by 1 inch. One scribing projector was used for enemy symbology which was displayed in red. The other projector was used for friendly and control measure symbology which was displayed in green.

(3) The two reference projectors were used very little during the experimentation since the map backgrounds chosen as a result of the map background conference (see part two, chapter I, section II, subparagraph I-4f) were not available on Vigicon slides. The only available Vigicon map slides contained white symbology on a black background. The map backgrounds decided upon at the conference required the symbology to be in color. A 35-millimeter Kodak Carrousel, Model 800, with a BUHL EFL 1.7 f:2.8 folded optic lens was used by the testers to rear-project the required backgrounds onto the screen for legibility testing. The carrousel was manually operated and had 80 sequentially addressable

slide positions. The slides projected by this method were identical to those used for the CRT group display projected map backgrounds.

(4) The spotting projector used an X-Y servomechanism to control the position of the projected cursor symbol. The symbol was a white circle with a crosshair. It was etched on an opaque 1-inch square plate which was driven by the servos.

b. *CRT - CRT projection display.*

(1) The CRT projection display used a rear screen projection technique to project a 5-foot by 5-foot color display onto a rigid screen that was located 10 feet from the projectors. The display was a composite image projected from two CRT projectors and a carousel slide projector.

(2) The CRT projectors (one red and one green) used high speed magnetic deflection systems to generate symbols by a stroking technique with a maximum refresh rate of 60 hertz. The red projector was used to project enemy symbology. The green projector was used to project friendly symbology. The display image area on the face of the CRT projectors was 3.25 inches by 3.25 inches.

(3) A 35-millimeter Kodak Ectographic, Model RA-960, with a BUHL EFL 1.7 f:2.8 lens was used to rear-project the required backgrounds onto the screen. The carousel had 80 computer-addressable slide positions.

c. *Photochromic - photochromic film display.*

(1) The photochromic film display used a rear screen projection technique to project a 6-foot by 4 1/2-foot display onto a non-rigid screen that was located 10 feet from the projector. The dynamic symbology and the map background were merged prior to their projection.

(2) The dynamic symbology was written on an erasable photochromic film by an ultraviolet laser which was deflected with special high speed galvanometers. The clear film was darkened by the laser beam. The resulting dynamic symbology was merged with a 70-millimeter color map slide of a standard military topographic map. This composite image was then projected onto the group display with a xenon projection lamp light source. The resulting dynamic symbology appeared in a dark blue color against a color map background. The projector had 60 computer-selectable map slide positions.

(3) The dynamic symbology required continual refresh since the film continually faded to a clear state. The refresh rate was dependent upon the number of symbols contained in the display and the selected fade rate. The film could be advanced to an unused area whenever desired.

(4) A blue-green laser which was also deflected by high speed galvanometers was used to display a cursor. The blue-green laser beam passed through the photochromic film without affecting it and was projected directly onto the large screen.

d. Evaluation.

(1) Evaluation for requirement number 1.

(a) Requirement 1. The group display output device must be able to display the 64-character ASCII set; the FM 21-30 symbols listed below; symbology added to the symbol generator by the user; circles; ellipses; and freehand graphics such as symbols for boundaries and axis of advance. The following symbols should be a part of the permanent symbol generator. FM 21-30 illustrates each symbol and provides examples of the use of the symbols.

Military Unit Symbols

HEADQUARTERS
CENTER OF MASS
TRAINs

NOTE: Military unit symbols must be displayed as actual or proposed. In addition, they must denote whether the represented unit is a task force.

Branch Duty Symbols

AIRBORNE	ARMOR	ENGINEER
AIR DEFENSE ARTILLERY	AVIATION	INFANTRY
AIRMOBILE	CAVALRY	MAINTENANCE
ANTITANK	CHEMICAL	PSYCHOLOGICAL OPERATIONS
FIELD ARTILLERY	ENGINEER, BRIDGE	SIGNAL
		TRANSPORTATION

Graphic Symbols

OBSERVATION POST	AMMUNITION SUPPLY POINT, ALL TYPES (combat service support installation)
COORDINATING POINT	AID STATION (combat service support installation)
MINE, ANTITANK	
MINE, ANTI PERSONNEL	
POL POINT, GROUND (combat service support installation)	

Line-Type Graphic Symbols

SOLID LINE
TRENCH, BASIC SYMBOL
WIRE, CONCERTINA, SINGLE

DASHED LINE
TANK OBSTACLE, TYPE UNSPECIFIED
LINE OF CONTACT (defensive frontline trace)

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	Met

(c) Discussion. The list of symbols which the scribe and the CRT systems were capable of displaying was mutually agreed upon by MASSTER and each vendor. The list of symbols did not include all of the symbols specified by the requirement. However, the scribe and the CRT systems were able to display the symbols agreed upon. The photochromic system was able to display the symbols specified by USAMC-ECOM. All three systems would have had the required symbols in their symbol library if the designers had been given the above list. Therefore, all three systems were rated as having met the intent of the requirement.

(d) Data. The number of symbols which were contained in each system's symbol library are shown in figure 2-6 below.

Symbol	Required	Scribe	CRT	Photochromic
Alphanumeric	64*	64*	64*	64*
Military unit Type	3	5	5	5
Branch duty	16	41	13	25
Individual graphic	7	16	7	6
Line-type graphic	6	4	2	4

*The symbols were the same as those contained in the 64-character ASCII set.

Figure 2-6. Number of symbols in group display symbol library.

(2) Evaluation for requirement number 2.

(a) Requirement 2. The group display scene must appear to be an enlargement of the console display scene. The symbol style and proportion must match those used on the console.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	Met

(c) Discussion. All scenes transferred to the group displays from the graphic consoles appeared to be enlargements of the console display scenes.

(3) Evaluation for requirement number 3.

(a) Requirement 3. A minimum of three colors is required. Three colors allow friendly, enemy and control measure symbols to be color coded. Four to six colors are desirable. Color selection must be based upon obtaining a high degree of contrast in relation to the map backgrounds the symbols will be displayed upon.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	No

(c) Discussion. In addition to color, enemy military unit symbols on the scribe and CRT group displays were distinguished by a notch or dovetail in place of the right verticle edge of the symbol rectangle. Data indicated that color was the primary distinguishing factor used by observers and that shape coding was unnecessary when color was used.

1 Scribe. The group display dynamic symbology was in two colors. It had the potential for a three color dynamic symbology display if one of the reference projectors had contained a scribing mechanism. Enemy symbols were displayed in red. Friendly symbols were displayed in green. The contrast of these symbols against the level 4 and level 6 map backgrounds was satisfactory. The standard military topographic map projection was predominantly white, and contrast of the red and green symbols against this background was low. When the filters were changed, the contrast of white and yellow symbols against these same backgrounds was excellent for all but the topographic map. The contrast on the topographic map was satisfactory.

2 CRT. The group display dynamic symbology was in two colors. Enemy symbols were displayed in red. Friendly symbols were displayed in green. The contrast of the symbols against the level 4 and level 6 map backgrounds was satisfactory. The projection of the standard military topographic map was predominantly white, and contrast of the symbols against this background was poor.

3 Photochromic. The group display dynamic symbology was in one color only. Enemy military unit symbols were distinguished by a double edged rectangle. The contrast of the dark blue dynamic symbology against the level 4, level 6, and standard military topographic map backgrounds was satisfactory.

(4) Evaluation for requirement number 4.

(a) Requirement 4. The group display should be fully legible under normal office lighting (70 foot-candles at desk top level). This requirement could be relaxed to as low as 30 foot-candles. Full legibility is defined as easy identification by every viewer in an audience of 20 people of every symbol in a tactical situation display.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	Met

(c) Discussion.

1 Scribe. The red and green symbology was easily seen on the level 4 and level 6 map backgrounds under normal office lighting. Easy viewing of the symbols against the standard military topographic map required a reduction in the ambient light to the 30 foot-candle condition. However, white and yellow symbols displayed against the topographic map background were fully legible under normal office lighting.

2 CRT. The symbology was easily seen on the level 4 and level 6 map backgrounds under the 30 foot-candle ambient light condition. Higher light levels or display of the standard military topographic map made viewing uncomfortable.

3 Photochromic. The symbology was easily seen on all three map backgrounds (level 4, level 6, and the standard military topographic map) under normal office lighting.

(5) Evaluation for requirement number 5.

(a) Requirement 5. The symbol size should be variable. However, the device must be designed with one optimum symbol size in mind. The selected size should be independent of the size selected for the console. However, when a display is initially transferred to the group display, the operator should have the option of allowing it to appear in a size proportioned to the size selected on the console.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	No	No

(c) Discussion.

1 Scribe. The system allowed for eight discrete symbol sizes. The symbol size of the entire display was changed and the apparent locations of the symbols remained the same.

2 CRT. Two discrete sizes of alphanumeric and military unit symbols were available. However, size change could be effected for individual symbols only. Changing the size of the entire display required the operator to change the size of every symbol in the display.

3 Photochromic. Only one symbol size was available.

(6) Evaluation for requirement number 6.

(a) Requirement 6. The display area must be large enough to display a tactical situation (maximum of 75 military unit symbols for a division) with a minimum amount of symbol clutter, but it must not be so large that it causes the audience undue eyestrain or head movement. The group display must be of sufficient size to comprehensibly present a tactical situation display to an audience of at least 20 people.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	Met

(c) Discussion.

1 Scribe. The size of the group display was satisfactory.

2 CRT. The size of the group display, although rated as meeting the requirement, was marginal for the symbol size used. The display was rated incomprehensible when the total number of military unit symbols exceeded 50. When placed as close as possible, with no overlap, 72 friendly or 66 enemy military unit symbols completely filled the screen. This screen symbol capacity met player requirements during the CPX as the maximum number of symbols used during the CPX was 36.

3 Photochromic. The size of the group display was satisfactory.

(7) Evaluation for requirement number 7.

(a) Requirement 7. The displayed symbology must not have any discernible flicker.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	No	Met

(c) Discussion.

1 Scribe. There was no discernible flicker.

2 CRT. Many observers complained about eyestrain after watching the group display for short periods. This was due to a discernible flicker which became more pronounced as the number of dynamic symbols increased. A separate refresh buffer (one not shared with the console) could have minimized the flicker.

3 Photochromic. The dynamic symbology did not appear to flicker. However, the background did. This was caused by the xenon projection lamp. The flexible screen added to the problem when air currents caused it to move. The background movement and projection lamp flicker are not desirable. However the display observers did not complain.

(8) Evaluation for requirement number 8.

(a) Requirement 8. The brightness of each dynamic symbology color and of each map feature color should be under user control. The user must, as a minimum, be able to vary the overall brightness of the dynamic symbology and the overall brightness of the map background.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	No	No

(c) Discussion.

1 Scribe. Dynamic symbology colors and the overall background brightness were individually controlled by adjusting the projection lens aperture settings. This was done manually at each projector.

2 CRT. Overall dynamic symbology brightness was controlled by adjusting a brightness knob on each projector. The background brightness control (a high-low intensity switch) did not meet the intent of this requirement.

3 Photochromic. The brightness of the overall display was adjusted by a projection lamp brightness control. This affected the brightness of both the background and the dynamic symbology.

(9) Evaluation for requirement number 9.

(a) Requirement 9. Data items superimposed against a map background on the group display output device must appear to be no more than 100 meters from the specified map location. This 100-meter limit applies for any method of data item location: keyboard coordinate entry, coordinates transmitted from an outside ADP source, points transmitted from the map overlay input device, or direct entry by pointing to the location on the console display. The limit applies regardless of the size of the area of coverage being viewed.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	No

(c) Discussion. None of the group displays demonstrated the ability to display data items consistently within 100 meters of their specified map location. Average symbol placement inaccuracies for the various methods of data item location are shown in figure 2-7. Detailed data is contained in part three, sections V, XVII, and XX.

<u>Method of input</u>	<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
DEVTOS	179	142	NA
Overlay input device	119	110	NA Data
Data manipulation			
Keyboard, add	212	176	87
Keyboard, move	215	174	84
Joystick, add	737*	NA	413*
Joystick, move	886*	NA	427*
Trackball, add	NA	264*	NA
Trackball, move	NA	337*	NA
Light pen, add	NA	346*	NA
Light pen, move	NA	268*	NA

*The symbols were located by using the console background as a reference before their subsequent transfer to the group display. The nonsynchronization of the console and group display backgrounds was the primary cause of the large placement inaccuracy.

Figure 2-7. Group display symbol average placement inaccuracy (meters).

(10) Evaluation for requirement number 10.

(a) Requirement 10. Data items are located either with single points (e.g., a military unit or a coordinating point) or with multiple points (e.g., a unit boundary or a trench line). Data items located with single points must be completely displayed if the point is inside the selected area of coverage. If any part of a multiple point data item is in the selected area of coverage, that part within the area of coverage must be displayed. The part to be displayed must include all points of the data item up to and including those at the intersection of the item with an edge (or edges) of the map background.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	NA

(c) Discussion.

1 Scribe. Only the portions of a symbol located with a single location point that were within the selected map area of coverage were displayed. Multiple location point symbols (such as lines) which had one or more locating points outside the area of coverage were not displayed.

2 CRT. A symbol with a single location point was displayed only if all portions of the symbol were within the selected map area of coverage. Multiple location point symbols (such as lines) which had one or more locating points outside the area of coverage were not displayed.

(11) Evaluation for requirement number 11.

(a) Requirement 11. The group display output device should be capable of displaying map backgrounds for the three uses described below. As a minimum, the device must be capable of displaying map backgrounds for the first use.

1 Comprehension of the overall situation. For this purpose the user is not interested in being able to read all detail on the standard military topographic map, but he uses the map to provide general orientation for the superimposed symbology.

2 More detailed inspection of the terrain at or in the vicinity of a superimposed symbol or symbols. In this case the user is interested in a more exact relationship of the symbols to the terrain.

3 Terrain analysis without superimposed symbology. For example, when selecting the best terrain upon which to establish a defense or when planning a route of movement, the user wants to view the map background with no superimposed dynamic symbology.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	Met

(c) Discussion.

1 Scribe. The group display had the potential for meeting all three uses described in (a)1, (a)2, and (a)3 above. However, the map slides agreed upon at the map background conference (part two, chapter I, section II, subparagraph I-4f) were not available for this system even though considerable effort was expended in trying to obtain the required backgrounds. The production of quality color map images on a glass slide was a difficult and costly process.

2 The group display had the ability to meet the minimum requirement for display of backgrounds for the comprehension of the overall situation. The display of backgrounds for the uses described in (a)2 and (a)3 above was unacceptable because of their legibility.

3 Photochromic. The group display had the ability to meet all three map display purposes.

(12) Evaluation for requirement number 12.

(a) Requirement 12. Map backgrounds based on the UTM grid system will normally be displayed on the group display. However, the group display should be able to accomodate other military grid systems. The UTM grid system requires that the device be able to display areas of coverage which include the junction of two or more map sheets and the junction of two or more 100,000-meter grid zones.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	Met

(c) Discussion. The map backgrounds displayed on all three group displays used the UTM grid system. The maps displayed included the junction of map sheets and the junction of 100,000-meter grid zones.

(13) Evaluation for requirement number 13.

(a) Requirement 13. The group display must provide map background coverage for an area no less than 50 kilometers by 50 kilometers.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	NA	NA

(c) Discussion. This requirement was identified as a result of the experimentation. A 40-kilometer by 40-kilometer area of coverage was agreed upon at the map conference.

1 Scribe. The white-on-black background displays that were provided with the group display had the 40-kilometer by 40-kilometer area of coverage agreed upon.

2 CRT. Technical limitations of the photographic equipment at the Defense Mapping Agency limited the size of the map slides to a 32-kilometer by 32-kilometer area of coverage.

3 Photochromic. The map slides provided with the photochromic system had the 27-kilometer by 36-kilometer area of coverage which was specified by USAMC-ECOM.

(14) Evaluation for requirement number 14.

(a) Requirement 14. The backgrounds used for display of the *overall* tactical situation must be identical in area of coverage and level of detail to the backgrounds used on the console for the same purpose. This is the primary background type required for the group display.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	Met	Met

(c) Discussion. The console and group display backgrounds provided with the CRT and photochromic systems were identical in all respects.

(15) Evaluation for requirement number 15.

(a) Requirement 15. The map backgrounds which are used to present the *overall* division situation must be fully legible when viewed under the ambient light requirement for dynamic symbology legibility specified in requirement 4 above. Full legibility is defined as the ability of every individual in the audience to easily identify every item of map data on the displayed background.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	Met

(c) Discussion. The level 4 and level 6 maps meet the map requirement for the comprehension of the overall tactical situation display. The level 4 map on the CRT and photochromic group displays and the level 6 maps on all three group displays were fully legible.

(16) Evaluation for requirement number 16.

(a) Requirement 16. In addition to the *overall* tactical situation display background requirement, if the display technique permits, the ability to display a map background with a degree of detail equal to the standard military 1:50,000 topographic map and with an area of coverage no less than 50 kilometers by 50 kilometers is desirable. The legibility of map detail on this background should be no less than that of the standard topographic map.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	NA	NA

(c) Discussion. The standard military topographic maps provided for the group displays had less than a 50-kilometer by 50-kilometer area of coverage. However, all map detail on these maps was fully legible at the face of the screen for the scribe and photochromic group displays.

(17) Evaluation for requirement number 17.

(a) Requirement 17. The display of blowups which are identical to those used on the console is desirable.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	NA	NA

(c) Discussion. Backgrounds were not provided for this purpose. The map conference focused on map requirements for the display of overall tactical situation. However, both the scribe and CRT systems could scale the display of the dynamic symbology to match any map background magnification.

(18) Evaluation for requirement number 18.

(a) Requirement 18. All displays on the consoles should be displayable on the group display. As a minimum, displays of the *overall* tactical situation on the console must be displayable on the group display.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	Met

(c) Discussion. The three systems were able to display any console scene on their group display output devices.

(19) Evaluation for requirement number 19.

(a) Requirement 19. Display scenes on the group display output device must be displayed independent of display scenes on the console.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	Met

(c) Discussion. The three systems had this ability.

(20) Evaluation for requirement number 20.

(a) Requirement 20. Displays from the interactive graphic display console are transferred to the group display by pressing the GROUP DISPLAY pushbutton on the console. This action causes both the map background and the selected dynamic symbology to be displayed on the large screen. Once the transfer has been initiated, the display must appear on the large screen within 15 seconds. The capability to have the display appear within 5 seconds is highly desirable.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	Exceeded	No

(c) Discussion.

1 Scribe. The transfer of a complete tactical situation display took from 4 to 6 minutes depending upon the number of symbols in the display. This time could have been cut in half if the scribing projectors had been able to work simultaneously.

2 CRT. The transfer of a complete tactical situation display took less than five seconds.

3 Photochromic. The transfer of a complete tactical situation display took from 1 to 6 minutes. The time was dependent upon how many symbols were in the display and how many refreshes were required to darken the dynamic symbology to the point where it was legible. The number of refreshes required was variable between 2 and 10. If the photochromic film had been darkened sufficiently with only one refresh, transfer of a complete display would have been accomplished in less than 40 seconds.

(2) Evaluation for requirement number 21.

(a) Requirement 21. If discrete map backgrounds are used, a means is required for their registration. Registration must require the operator to only point at and input the UTM coordinates of any two grid intersections diagonally located in relation to each other. The background must not have to be exactly horizontal, vertical, or centered. Once registered, the background must be available for display without re-registration each time it is retrieved.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	No

(c) Discussion.

1 General. The designers of the three systems assumed that the map background slides (film chips) would be exactly the same size and that they would be positioned in the slide holder exactly the same way. They further assumed that the slides would be exactly horizontal and vertical in the holder. These assumptions, while good for the convenience of the system software designer, imposed an unrealistic requirement which could not be met by the Defense Mapping Agency. The slides prepared by the Defense Mapping Agency were not positioned identically in the slide holders. Therefore, display of a new map background required realignment of the electronic image to match the map background each time a different map was displayed. This was an unnecessary burden on the user and defeated the purpose for having quickly accessible backgrounds.

2 Scribe. The system required the map image to be square in addition to the above constraints. Also, three people were required to register a map. Once a map was registered, it did not require re-registration. The system allowed the user to define 16 different displays. These displays could all be defined for one map background area of coverage, or a different background area of coverage could be defined for each of the 16 displays. A display was composed of specific data item types on a particular background slide.

3 CRT. The system did not allow for user registration of map backgrounds. The system programmer could register a new map area by means of a software patch, but the normal means was to input the map registration data to a computer at the General Dynamics Laboratory in San Diego, California. The computer computed the registration data which was then input to the display system. All maps displayed by the system were part of a "big window." The big window was a square area which encompassed all of the maps to be displayed by the system. If a map to be registered was not within the big window, the area of the big window required enlargement. A map in the big window was identified by a number. The lower left corner of the maps in the big window were identified by an X and Y offset from the lower left corner of the big window. All UTM coordinates of the map were converted to big window coordinates. Conversion was based on the X-Y offset, the scale of the map, and the area of coverage of the map. The area of coverage was assumed to be square. A map, once registered, did not need to be re-registered when retrieved. However, the map images, when retrieved, had to be exactly horizontal, vertical, centered, and to scale. This is an unrealistic requirement.

4 Photochromic. The system designer assumed that the map chip was positioned in the slide a specific way. The registration of a displayed map area required the operator to enter data which matched the map image area on the screen with the displayed map image. The operator typed in the coordinates of the lower left corner of the map area (with a correction factor in X and Y to account for the fact that the corner was not exactly at a grid line intersection). The coordinates included the area of the world (e.g., 14R), the 100,000-meter grid zone designator (e.g., PL), and eight digits. The operator then typed the map scale and four adjacent 100,000-meter grid zone designators. The grid zone designators were the designator previously entered as a part of the lower left coordinate and the grid zone designators to the north, east, and north-east. When map background areas were changed, the new map area required re-registering even though it may have been previously retrieved and registered.

(22) Evaluation for requirement number 22.

(a) Requirement 22.

1 A number of control switches or knobs are required on the group display output device. The controls must be located near the face of the screen, for easy access to a briefer or to an individual performing viewability adjustments to suit the audience.

2 The controls listed below are required. Other controls may be required depending upon the display technique used. For example, individual dynamic symbology and map background focus knobs may be necessary.

a Dynamic symbology brightness control knob. Turning the knob one way or the other increases or decreases the *overall* brightness of displayed dynamic symbology within the range from maximum brightness to the dynamic symbology being completely faded from the screen.

b Map background brightness control knob. Turning the knob one way or the other increases or decreases the *overall* brightness of the displayed map background. The brightness is controllable from maximum brightness to the map background being completely faded from the screen.

3 The following controls are desirable:

a Color brightness control knob(s). One knob is provided for each color of dynamic symbology. The knob has the same function and range as the dynamic symbology brightness control knob except that it controls the brightness of an individual color.

b Map feature brightness control knob(s). These controls are necessary if the ideal map background display is practical. One knob is required for each color used to identify a specific map feature (e.g., roads, vegetation, rivers). The function and range of the knob is the same as the map background brightness control knob except that it controls the brightness of an individual map feature color.

c Symbol size control knob. Turning the knob one way or the other varies (within a specified range) the size of all data items except line-type graphic items, circles, and ellipses. When the control is used, all parts of the data item (e.g., the rectangle, the branch duty symbol, the left identification, the right identification, and the echelon) are either enlarged or reduced proportionately. Changing the size of the symbol must not change the symbol's apparent map location.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	NA	NA

(c) Discussion. This requirement was identified as a result of the experimentation.

2-11. Map Overlay Input Device. A description of the device in the scribe and CRT systems which performed functions corresponding to the requirements stated for the map overlay input device follows. The photochromic system did not have a comparable device.

a. *Scribe - graphic input device*. A tracking head was suspended over the working area by an aluminum tubular support. The material to be traced, which could be up to 28-inches square, was placed on the table below. A tracing pencil at the end of a rod which was attached to the tracking head was moved over the material to be reproduced. A carriage in the head was moved by the end of the tracing rod, and its movement caused a pair of potentiometers to be rotated. The potentiometers were mounted orthogonally to each other and were excited by the system reference voltage. The outputs of the unit were two analog voltages that were proportional to the X and Y position of the tracing pencil point. These analog signals were routed to the controller, where they were digitized and sent to the display processor for processing. The processed signals were used to control one of the group display scribing projectors.

b. *CRT - map table device*. The map table device was a GRAF/PEN GP-2 that was manufactured by Science Accessories Corporation, a subsidiary of North American Phillips. The GRAF/PEN system consisted of a stylus, a tablet, a control unit, and an H-316 computer interface. The tablet was 36 inches square. The stylus combined a ballpoint pen and a tiny spark gap to generate a sound pulse. This sound pulse was received by strip sensors along two perpendicular sides of the tablet and was converted by the control unit to a 12-bit X and Y coordinate. The device transmitted a coordinate pair each time the stylus touched the table.

c. Evaluation.

(1) Evaluation for requirement number 1.

(a) Requirement 1. The map background used on the map overlay input device must be registered in such a manner that a data item entered as a series of points from either the overlay or the map will, if displayed on the console or group display, have the points *displayed* no more than 100 meters from the points entered through the device.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	No	NA

(c) Discussion.

1 General. Detailed placement inaccuracy data is contained in part Three, section XVII.

2 Scribe. The average placement inaccuracy of data items input to the group display was 119 meters. The worst case was 320 meters. Data was not collected for the console, since the overlay was input directly to the group display and no entry was made into the data base.

3 CRT. The average placement inaccuracy of data items input to the console and group display was 197 and 110 meters, respectively. The worst case for these devices was 500 and 325 meters, respectively.

(2) Evaluation for requirement number 2.

(a) Requirement 2. The device must be large enough to accommodate the map area of coverage for the majority of division tactical situations (i.e., no less than 50 kilometers by 50 kilometers). The size of a 50-kilometer by 50-kilometer area on a scale of 1:50,000 (the scale of maps most widely used in the division) is 1 meter by 1 meter.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	NA

(c) Discussion.

1 General. Neither system's device met this requirement. However, the techniques used had the potential for meeting the requirement.

2 Scribe. The maximum area of coverage for a 1:50,000 scale map was a 35.5-kilometer square area.

3 CRT. The maximum area of coverage for a 1:50,000 scale map was a 45.7-kilometer square area.

(3) Evaluation for requirement number 3.

(a) Requirement 3. The registration of a map on the device must only require an operator to point at and input the UTM coordinates of any two grid intersections diagonally located in relation to each other. The map must not have to be exactly horizontal, vertical, or centered.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	NA

(c) Discussion.

1 Scribe. Registration of a map required that the map be exactly horizontal, vertical, centered, and square. It also required the operator to point at and input the coordinates of an extreme corner point.

2 CRT. Registration of a map required that the coordinate of its two extreme corner points be input. The operator did not have the option of inputting any two diagonally located points. The map had to be exactly horizontal, vertical, and square. It had to be registered each time the device was used.

(4) Evaluation for requirement number 4.

(a) Requirement 4. The device must be able to accept for registration maps which use the UTM grid system. Map areas to be registered may include the junction of two or more map sheets, and the junction of two or more 100,000-meter grid zones.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	NA

(c) Discussion. The scribe and CRT map overlay input devices met this requirement.

(5) Evaluation for requirement number 5.

(a) Requirement 5. The device should accept maps of any scale but must, as a minimum, accept maps with a scale of 1:25,000, 1:50,000, 1:100,000, and 1:250,000.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	NA

(c) Discussion. The scribe and CRT map overlay input devices met this requirement.

(6) Evaluation for requirement number 6.

(a) Requirement 6.

1 The procedure for entry of freehand graphic data should be similar to the procedure listed below:

a On the console, select the desired area of coverage for monitoring the input. (This should not have to be the exact area registered on the input device.)

b Press the OVERLAY DEVICE pushbutton on the console. This activates the map overlay input device.

c Press the desired graphic data line segment, the desired data category, and the desired color pushbuttons on the console. All points input from the overlay device are displayed and connected by the selected graphic line segment in the selected color. The desired type of line segment, the data category, and the color can be changed at any time by pressing the appropriate line-type, category, and color pushbuttons.

d If the map on the input device is not registered, type in the grid coordinates of two diagonally located grid intersections and point to those points on the map. This step should not have to be performed again unless the map is moved or a new map is positioned on the device.

e Press the CREATE ITEM pushbutton on the input device.

f Input the desired data item by pointing to the series of points defining the data item on the overlay. As each succeeding point is selected, the resulting cumulative line segment should appear on the console. If the operator is not satisfied with the last few line segments, he should be able to delete them by pressing the BACKTRACK pushbutton. If the operator is not satisfied with the entire item, he should have the option of starting again by pressing the CREATE ITEM pushbutton again.

g Press the COMPLETE pushbutton.

h Input additional items by repeating e, f, and g above.

i After all entries have been made, the device is turned off by deactivating the OVERLAY DEVICE pushbutton on the console.

2 The procedure outlined above can also be used for the input of freehand graphic data directly from a map. As far as the device is concerned, it is immaterial whether the data input is from an overlay or directly from the map as long as the user specifies the category under which each data item is to be displayed.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	NA

(c) Discussion.

1 Scribe. The input of freehand graphic data from an overlay was direct to either of the scribing projectors. The scribing stylus was directly controlled by moving the tracing pencil on the input device. The data entered by this method did not become a part of the data base and therefore was not displayed on the console. The ability to enter data items into the data base as a series of points connected by line segments existed. However, the input of overlays by this method was not tested.

2 CRT. The timeliness and ease of use for this device met the intent of the procedure. However, input through this device had some limitations. All items input through the device appeared on the display as a solid line in a single category and were displayed in only one color. These items could be modified at the console but this required a great deal of operator interaction.

(7) Evaluation for requirement number 7.

(a) Requirement 7. A distance measurement capability is desirable. The measured distances must be within 5 percent of the actual distance. The procedure should be similar to the procedure listed below:

- 1 Press the OVERLAY DEVICE pushbutton on the console.
- 2 If the map on the input device is not registered, type in the coordinates of two diagonally located grid intersections and point to these points.
- 3 Press the DISTANCE MEASUREMENT pushbutton.
- 4 Measure the desired cumulative distance on the map by pointing to the start point, succeeding points of inflection, and the end point.
- 5 Press the COMPLETE pushbutton. This causes the distance measured to appear in meters on the console screen.
- 6 Measure additional distances by repeating 4 and 5 above.
- 7 Turn off the device by deactivating the OVERLAY DEVICE pushbutton.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	NA

(c) Discussion.

1 General. Both systems met the timeliness and ease of use intent for this requirement. However, the inaccuracy of the systems was not acceptable. Detailed inaccuracy figures for the scribe and CRT devices are contained in part three, section XIV.

2 Scribe. The average distance measurement inaccuracy of the device was 7.6 percent of the actual distance.

3 CRT. The average distance measurement inaccuracy of the device was 7.1 percent of the actual distance.

(8) Evaluation for requirement number 8.

(a) Requirement 8. Maintainability of the device should be such that any unscheduled maintenance action does not exceed 30 minutes.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	NA	NA

(c) Discussion. This requirement was identified as a result of the experimentation.

2-12. Map Overlay Output Device. A description of the device, in each of the three candidate systems, which performed functions corresponding to the requirements stated for the map overlay output device follows.

a. Scribe - *hard copy reproducer*.

(1) The hard copy reproducer was designed to accept standard Vigicon large screen display plotting or reference slides. The hard copy (black and white) was a composite of successive entries of Vigicon slides. The composite hard copy represented a Vigicon scene that was displayed on the large screen display at the time the slides were in the Vigicon projectors.

(2) The hard copy reproducer was a modified 3M Model 200 Filmac Recorder Printer. The original printer was designed to accept 35-millimeter microfilm and to make a single 18- by 24-inch hard copy reproduction. Modifications included redesign to accept a Vigicon slide and addition of a control to make successive reproduction overprints prior to "rolling out" the resultant hard copy. The reproductions were made on opaque paper.

b. CRT - *hard copy plotter*.

(1) The hard copy plotter was a California Computer Products (CALCOMP) Model 502. This was a digital incremental flatbed plotter that had a maximum plotting size of 34 inches by 31 inches. It provided a maximum speed of 3 inches per second in X or Y and 4.2 inches per second diagonally.

(2) The plotter could produce a multicolor display by stopping the plot and changing to a different color pen. Copies were produced without apparent interruption of other system functions.

c. Photochromic - *hard copy reproducer*. The hard copy reproducer user a laser technique similar to that used for the photochromic film display device. The dynamic symbology was written on a 22-inch by 34.5-inch sheet of photochromic film by an ultraviolet laser which was deflected with special high speed galvanometers. The film was then moved to a developing station which used heat to fix the symbols on the film. The developed film was the copy. The symbols were black and were on a transparent background. Up to 99 copies of the same display could be produced sequentially.

d. Evaluation.

(1) Evaluation for requirement number 1.

(a) Requirement 1. The map overlay output device must be able to display the 64-character ASCII set; the FM 21-30 symbols listed below; symbology added to the symbol generator by the user; circles; ellipses; and freehand graphics such as symbols for boundaries and axis of advance. The following symbols should be a part of the permanent symbol generator. FM 21-30 illustrates each symbol and provides examples of the use of the symbols.

Military Unit Symbols

HEADQUARTERS
CENTER OF MASS
TRAIN

NOTE: Military unit symbols must be displayed as actual or proposed. In addition, they must denote whether the represented unit is a task force.

Branch Duty Symbols

AIRBORNE	ARMOR	ENGINEER AIR DEFENSE
ARTILLERY	AVIATION	INFANTRY
AIRMOBILE	CAVALRY	MAINTENANCE
ANTITANK	CHEMICAL	PSYCHOLOGICAL OPERATIONS
FIELD ARTILLERY	ENGINEER, BRIDGE	SIGNAL
		TRANSPORTATION

Graphic Symbols

OBSERVATION POST	AMMUNITION SUPPLY POINT, ALL TYPES (combat service support installation)
COORDINATING POINT	
MINE, ANTITANK	AID STATION (combat service support installation)
MINE, ANTI PERSONNEL	
POL POINT, GROUND (combat service support installation)	

Line-Type Graphic Symbols

SOLID LINE
TRENCH, BASIC SYMBOL
WIRE, CONCERTINA, SINGLE

DASHED LINE
TANK OBSTACLE, TYPE UNSPECIFIED
LINE OF CONTACT (defensive frontline
trace)

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	No	Met

(c) Discussion. The list of symbols which the scribe and the CRT systems were capable of displaying was mutually agreed upon by MASSTER and each vendor. The list of symbols did not include all of the symbols specified by this requirement. However, the scribe and the CRT systems were able to display the symbols agreed upon. The photochromic system was able to display the symbols specified by USAMC-ECOM. All three systems would have had the required symbols in their symbol library if the designers had been given the above list. Therefore, the scribe and photochromic devices were rated as having met the intent of the requirement. However, the CRT device was not able to output symbology added to the symbol generator by the user.

(d) Data. The number of symbols which were contained in each system's symbol library are shown in figure 2-8 below.

Symbol	Required	Scribe	CRT	Photochromic
Alphanumeric	64*	64*	64*	64*
Military unit				
Type	3	5	5	5
Branch duty	16	41	13	25
Individual				
graphic	7	16	7	6
Line-type				
graphic	6	4	2	4

*The symbols were the same as those contained in the 64-character ASCII set.

Figure 2-8. Number of symbols in map overlay output symbol library.

(2) Evaluation for requirement number 2.

(a) Requirement 2. The symbol style and proportion of output must match that used on the interactive graphic display console.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	No	Met

(c) Discussion.

1 General. The scribe and photochromic outputs were exact copies of the console displays.

2 CRT. The military unit symbol alphanumeric designators (e.g., identifications and echelon) were a disproportionate distance from the flag symbol. Many other alphanumerics were not located as they should have been.

(3) Evaluation for requirement number 3.

(a) Requirement 3. A minimum of three colors is desired. Three colors allow friendly, enemy, and control measure symbols to be color coded. Four to six colors are desirable. Color selection must be based upon obtaining a high degree of contrast in relation to the map backgrounds the overlays will be displayed against.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	Met	No

(c) Discussion.

1 Scribe. The symbols were black on an opaque white background. Shape coding was used to distinguish between enemy and friendly military unit symbols.

2 CRT. The device had a number of different colored pens. The operator had the option of producing overlays in any two colors since the device paused after plotting the friendly data items. At this point, the operator could exchange pens before plotting the enemy data items. The system could have easily been programmed to pause at the end of each data category. Therefore, the device is rated as having met this requirement.

3 Photochromic. The symbols were black on a transparent background. Shape coding was used to distinguish between enemy and friendly military unit symbols.

(4) Evaluation for requirement number 4.

(a) Requirement 4. The overlay must be capable of being output on transparent material. This is not intended to preclude output on other material such as paper.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	Met	Met

(c) Discussion.

1 Scribe. The output was on opaque paper.

2 CRT. The output could be drawn on either transparent material or paper.

3 Photochromic. The output was on tinted transparent material.

(5) Evaluation for requirement number 5.

(a) Requirement 5. The symbology when shown against a standard military topographic paper map must be fully legible in as little as 30 foot-candles of ambient light.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	No

(c) Discussion.

1 Scribe. The output was on opaque paper; therefore, it could not be shown against a paper map background.

2 CRT. The output was not fully legible primarily because the alphanumerics were too small and had little spacing between adjacent characters. The contrast of red symbols with the background was poor since they were translucent. Opaque inks should be used for transparent overlays.

3 Photochromic. The boundaries, declutter lines alphanumerics, and friendly military unit symbols were not dark enough. The enemy military unit symbols were dark enough; however, they did not appear sharp and clear due to "blooming."

(6) Evaluation for requirement number 6.

(a) Requirement 6. One symbol size is all that is required. The size should be selected so that the symbols are fully legible to the individuals working with a map board under 30 foot-candles of light. However, the symbols must be small enough to present a tactical situation display that is not unduly cluttered.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	No	Met

(c) Discussion.

1 Scribe. The intent of this requirement is that the symbols be large enough to be legible against a paper map background. The overlay was on opaque paper and was not to scale.

2 CRT. The alphanumerics were too small and had little spacing between adjacent characters.

3 Photochromic. The symbol size was satisfactory.

(7) Evaluation for requirement number 7.

(a) Requirement 7. The overlays produced by the map overlay output device will be used with standard military paper maps. The data items on the overlay, when placed over the maps, must be no more than 100 meters from the symbol locations used in inputting the overlay to the display system.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	No	No

(c) Discussion.

1 General. Detailed data on data item placement accuracy is contained in part three, section XX.

2 Scribe. The scale of the output was not standard (i.e., 1:25,000, 1:50,000, 1:100,000, and 1:250,000).

3 CRT. The average placement inaccuracy was 302 meters against a 1:50,000 scale map.

4 Photochromic. The average placement inaccuracy was 118 meters against a 1:50,000 scale map.

(8) Evaluation for requirement number 8.

(a) Requirement 8. Every data item on a display scene selected for output as an overlay must be present on the hard copy produced by the device.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	Met

(c) Discussion.

1 Scribe. Symbols near the top edge were not completely displayed because they were output on the edge of the paper.

2 CRT. A few alphanumeric characters were missing on several outputs.

3 Photochromic. The device met this requirement.

(9) Evaluation for requirement number 9.

(a) Requirement 9. The map overlay output device copy size must be at least 1 meter by 1 meter.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	No	No

(c) Discussion.

1 Scribe. The intent of this requirement is that a 1:50,000 scale overlay output by this device have at least a 50-kilometer by 50-kilometer area of coverage. The scribe output was not to scale.

2 CRT. The device could output a 39-kilometer by 43-kilometer (78 cm by 86 cm) 1:50,000 scale overlay. However, 32 kilometer by 32 kilometer 1:50,000 scale overlays were generally output because of the console and group display map areas of coverage.

3 Photochromic. The device was able to output a 27 kilometer by 36 kilometer 1:50,000 scale overlay.

(10) Evaluation for requirement number 10.

(a) Requirement 10. The device should have the ability to provide copy to any scale desired. As a minimum, the operator must be able to specify scales of 1:25,000, 1:50,000, 1:100,000, and 1:250,000.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	Met	Met

(c) Discussion. Scribe. The scale of the output was nonstandard.

(11) Evaluation for requirement number 11.

(a) Requirement 11. All tactical display scenes on the interactive graphic display console should be reproducible in multiple copy on the map overlay output device.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	Met

(c) Discussion. The three devices were able to produce more than one copy. However, the multiple copy ability of the devices was marginal as is discussed in requirement 12 below.

(12) Evaluation for requirement number 12.

(a) Requirement 12. The procedure for producing hard copy on this device is similar to the procedure used for outputting a scene to the group display device. The scene must first be displayed on an interactive graphic display console. The PRODUCE OVERLAY pushbutton on the console is then pressed. After typing the desired number of copies, the console should be free to return to other display functions.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	No

(c) Discussion.

I Scribe. Graphic display console scenes were not directly reproducible on the output device. The scenes were first scribed on the group display projector slides. These slides were then used to make the hard copy. Multiple copies could be made; however, their production was not automatic.

2 CRT. Any scene on the console was directly reproducible on the output device without tying up the console. However, multiple copy reproduction was not automatic. Multiple copy reproduction required the redisplay of the scene on the console for each copy.

3 Photochromic. Graphic console display scenes were not directly reproducible on the output device. The scenes were first transferred to the group display. Up to 99 copies of the same display could be produced automatically one after the other. However, the system was not able to do anything else while these copies were being made.

(13) Evaluation for requirement number 13.

(a) Requirement 13. The time to produce one copy must not exceed 5 minutes. However, a time of 1 to 2 minutes per copy is extremely desirable.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	No	Exceeded

(c) Discussion.

1 Scribe. The maximum time required to produce one overlay on the device was approximately 3 minutes. The average time was slightly less than 3 minutes.

2 CRT. The maximum time required to produce one overlay on the device was approximately 31 minutes. The average time was 28 minutes.

3 Photochromic. The maximum time required to produce one overlay on the device was 48 seconds. The average time was 45 seconds.

(14) Evaluation for requirement number 14.

(a) Requirement 14. The map overlay output device should be capable of remote operation.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	NA	NA

(c) Discussion. This requirement was identified as a result of the experimentation.

(15) Evaluation for requirement number 15.

(a) Requirement 15. Maintainability of the device should be such that any unscheduled maintenance action does not exceed 30 minutes.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	NA	NA

(c) Discussion. This requirement was identified as a result of the experimentation.

2-13. Printer. A description of the device in the scribe and CRT systems which performed functions corresponding to the requirements stated for the printer follows. The photochromic system did not have a comparable device.

a. Scribe - medium speed printer. The printer was a Potter Model LP 3300 impact printer which was capable of printing 200 lines per minute at 132 characters per line. The output was on perforated 14 7/8-inch by 11-inch sheets of paper that had a capacity for 66 lines of print.

b. CRT - medium speed printer. The printer was a Versatec Model LP-1150 electrostatic printer which was capable of printing 500 lines per minute at 132 characters per line. The output was on perforated 8 1/2-inch by 11-inch sheets of paper that had a capacity for 54 lines of print.

c. Evaluation.

(1) Evaluation for requirement number 1.

(a) Requirement 1. The characters in the 64-character ASCII set are required for output by the printer. The size, style, and proportion of the characters must be fully legible to the user when they are viewed as lines of print in as little as 30 foot-candles of ambient light.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	NA

(c) Discussion.

I Scribe. The scribe printer met this requirement.

2 CRT. The CRT printer marginally met this requirement. Occasionally the print was faded and difficult to read. This was especially so whenever the lines of print were left in the print area for a short period of time (e.g., 5 to 10 minutes).

(2) Evaluation for requirement number 2.

(a) Requirement 2. The print area must be visible to the user.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	NA

(c) Discussion.

1 Scribe. Lines of print were not visible immediately after they were printed. Several more lines had to be printed or the page advanced before a particular line was visible.

2 CRT. The page had to be advanced for a line of newly received data to be seen.

(3) Evaluation for requirement number 3.

(a) Requirement 3. The size of printer output copy should be the standard 8 inches by 10 1/2 inches.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
No	No	NA

(c) Discussion.

1 Scribe. The size of the output was 14 7/8 inches by 11 inches.

2 CRT. The size of the output was 8 1/2 inches by 11 inches.

(4) Evaluation for requirement number 4.

(a) Requirement 4. Receipt of data from an outside ADP source must be automatic. When the printer is activated, an audible alert (adjustable by the operator down to zero volume) must indicate to the operator that output is being printed.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	No	NA

(c) Discussion.

1 Scribe. The printer did not have an adjustable audible alert. However, it marginally met the intent of the requirement since the noise made by the impact hammers was sufficient to alert the operator.

2 CRT. The printer did not have an audible alert. The electrostatic print process that was used could not be heard by the console operator.

(5) Evaluation for requirement number 5.

(a) Requirement 5. Output of alphanumeric data from the system's data base should only require the display of the desired categories and pressing of the PRINTER pushbutton. The pushbutton should remain lit until the output is produced; then it should automatically turn off.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	NA	NA

(c) Discussion. This requirement was identified as a result of the experimentation.

(6) Evaluation for requirement number 6.

(a) Requirement 6. The printer must be capable of outputting a full page of single-spaced alphanumerics within 30 seconds.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
Met	Met	NA

(c) Discussion.

1 Scribe. A full page of single spaced alphanumerics required approximately 20 seconds to be printed.

2 CRT. A full page of single spaced alphanumericics required approximately 7 seconds to be printed.

(7) Evaluation for requirement number 7.

(a) Requirement 7. Maintainability should be such that any unscheduled maintenance action does not exceed 30 minutes.

(b) Performance.

<u>Scribe</u>	<u>CRT</u>	<u>Photochromic</u>
NA	NA	NA

(c) Discussion. This requirement was identified as a result of the experimentation.

2-14. Alphanumeric Display Console. None of the three candidate systems had a device which performed functions corresponding to the requirements stated for the alphanumeric display console.

2-15. Analysis of Performance.

a. General.

(1) None of the systems evaluated during the experimentation fully met all of the requirements stated in section II, paragraph 2-6, of this chapter.

(2) The CRT system demonstrated the best performance overall. Its performance was primarily attributable to the system's software design which provided more capability and flexibility in the display and manipulation of data than was demonstrated by the other two systems. The performance of the CRT system was enhanced by the use of a magnetic disk storage unit which allowed for the storage of a greater number of display routines than provided by the other two systems. The routines were rapidly accessible by the display processor and were called upon as required.

(3) However, each system had some hardware and software capabilities which surpassed the performance of the other two systems in meeting some requirements. These capabilities are noted in the analysis of system device performance in b, c, d, e, and f below.

(4) Evaluated collectively, the performance of the three systems demonstrated that available hardware and software technology have the potential to meet the automated display system technical performance requirements described in this report.

b. Interactive graphic display console (individual display).

(1) The CRT console demonstrated the greatest interactive capability. The procedures used for data manipulation on this console were more comprehensive than the procedures used by the other two systems, and they provided the best visual feedback for verifying manipulations. However, the technique used on the photochromic console (the pressing of function pushbuttons in a specified sequence) was the easiest to learn and use.

(2) The CRT and scribe consoles provided for the storage and display of data items by category; the photochromic console did not. Category assignment, selection, and display on the CRT console was more flexible than on the scribe consoles.

(3) Display scenes could be stored on magnetic tape for later recall and display on the CRT and scribe consoles. The photochromic system had no on-line capability for storage and recall of display scenes.

(4) The CRT and photochromic consoles had a map background display capability; the scribe console did not. The lack of this capability was a serious shortcoming of the scribe consoles. Maps displayed on the CRT and photochromic consoles could be used for comprehension of the overall situation but did not provide sufficiently legible detail for terrain analysis.

(5) Neither the CRT nor the photochromic console met the ideal requirements for tailoring the displayed map background to the situation. Both systems used slide projections of discrete areas. The CRT console provided some flexibility in the level of map detail selection. This was accomplished through the use of slides with varying levels of map detail.

(6) When the console operator changed map background areas, currently selected dynamic symbology in the new area of coverage was automatically displayed on the CRT and scribe consoles. The CRT console display was more flexible since it did not require that the operator define specific categories for each map area as did the scribe console. Changing of map areas on the photochromic console required the operator to create a completely new scene.

(7) The consoles were rated as equal in their capability to provide alphanumeric, military unit, and graphic symbology. All three systems had the capability to add user-created symbols to their symbol library.

(8) The CRT console was the only one which provided a multicolor dynamic symbology display. However, it also required the lowest ambient light level for comfortable operator use. Dynamic symbols and map backgrounds (particularly the standard military topographic map) were most legible on the photochromic console, but the dynamic symbols were

displayed in one color only. The red and green dynamic symbols on the CRT console provided low contrast against the predominantly white display of the standard military topographic map. The photochromic console was the only console which had adjustable brightness controls for both the map background and the dynamic symbology.

(9) The screen on the scribe console was too small for the uncluttered display of a typical division overall situation; the size of the CRT and photochromic console screens was marginally acceptable. Both consoles in the scribe system used rectangular screens for the definition of a square map area. This resulted in unequal physical dimensions in the horizontal and vertical direction for a specific map distance and was very undesirable. The photochromic console display screen was physically separated from the keyboard and controls. This caused undue operator eye and head movement and was an undesirable feature.

(10) None of the consoles met the placement accuracy requirement for data items transmitted from DEVTO5 or for data items positioned with coordinates. The CRT console came the closest. Data items which were positioned by the movement of a cursor met the requirement and were most accurately displayed on the photochromic console. Data item positioning by movement of a cursor was the most difficult and the least accurate on the scribe consoles because of the lack of a displayed map background for referencing the symbol position.

c. Group display output device.

(1) All three group displays were capable of displaying map backgrounds for comprehension of the overall tactical situation. These backgrounds were identical to those used on the interactive graphic display console for the same purpose.

(2) The g. o displays were rated as equal in their capability to provide alphanumeric, military unit, and graphic symbology. All three systems were able to display user created symbols which had been added to the symbol library.

(3) The scribe display was best from a viewability stand point. The scribe and CRT group displays provided two color dynamic symbology; the photochromic system displayed dynamic symbols in one color. Dynamic symbols were most legible on the scribe group display. Map backgrounds (particularly the standard military topographic map background) were most legible on the photochromic group display. The red and green dynamic symbols of the scribe and CRT displays provided low contrast against the standard military topographic map; the scribe's yellow and white dynamic symbols and the photochromic's dark blue dynamic symbols provided good contrast against the same background. None of the systems met the requirement for adjustable brightness controls for the dynamic symbology and the map background.

(4) The photochromic and scribe group display image area was satisfactory. The CRT image area was marginal because of the dynamic symbol size used.

(5) On all three group displays, the group display scene appeared to be an enlargement of the scene transferred from the interactive graphic display console. The CRT group display was the only one which met the requirement for rapid transfer of displays from the consoles. Scenes on all three group displays were displayed independently of the console.

(6) None of the group displays met the data item placement accuracy requirement. The CRT display had the best placement accuracy for DEVTOS-transmitted data and for symbols located at the console by cursor positioning. The photochromic display had the best placement accuracy for symbols located at the console by keyboard coordinate entry.

d. Map overlay input device.

(1) The photochromic system did not have a map overlay input device. Neither the scribe nor the CRT device met the requirements for ease of use, area of map coverage, or placement accuracy.

(2) Both the scribe and CRT devices required that registered maps be exactly horizontal, vertical, and centered. The CRT device required re-registration of the same map each time the device was activated. This was undesirable. Both devices were capable of inputting data as a series of points. Each data item was input in a preprogrammed category, color, and line type. However, once the item was input, its category, color and line type could be changed at the CRT's interactive graphic display console; it was not possible to do this on the scribe console.

(3) The CRT device allowed for a larger area of map coverage than the scribe device and almost met the requirement. Neither device was significantly better than the other in placement accuracy.

e. Map overlay output device.

(1) The photochromic device was the best of the three evaluated. The CRT and photochromic device outputs were on transparent material and to standard map scales. The scribe device output was on opaque material and was not to scale. The CRT device provided the largest output; however, none of the devices met the map area of coverage requirement.

(2) The CRT device was capable of multicolor output. The other two devices provided output in a single color and required shape coding to distinguish friendly from enemy symbols. The photochromic and scribe device outputs matched the scene displayed on the console; the CRT device was unable to output user-created special symbols.

(3) All three devices were capable of providing multiple copy. The photochromic and scribe devices met the timeliness requirement for output of multiple copy; the CRT device did not.

(4) The placement accuracy on the scribe device was not tested since the output was not to scale. Neither the CRT nor the photochromic device met the placement accuracy requirement; however, the photochromic device came very close.

f. Printer.

(1) The photochromic system did not have a printer. The scribe printer was the better of the two evaluated.

(2) Both the scribe and the CRT printers had the required ASCII characters. The scribe copy met the legibility requirement. The CRT copy was marginally legible, when taken from the machine immediately after being printed. It faded to illegibility when the page was not advanced upon completion of the printing.

(3) Both printers met the timeliness requirement. Neither printer provided the required 8-inch by 10 1/2-inch copy size; however, the CRT copy was the commercial 8 1/2-inch by 11-inch size.

(4) Both printers required advancement of the paper to read a line of print.

23 July 1974

IBCS: AUTOMATED DISPLAYS
Test Number FM116

PART THREE - REDUCED DATA

I-1. Introduction.

- a. This part contains the reduced data for work segments 1 through 22. Each work segment contains a work statement that is followed by the reduced data for the scribe, the CRT, and the photochromic systems. The reduced data for each system is organized and presented in the order specified by the data reduction procedures of the work statement.
- b. The exception to this format is the data for work segments 1 and 2. The data for these work segments was collected prior to the experimentation, is not system peculiar, and is presented without reference to any system.
- c. Data was not collected for the photochromic system for work segments 14, 17, and 21. This system did not have the capability to perform the functions required for these work segments.
- d. The last section of this part contains the subobjectives and essential elements of analysis (EEA's) for each of the three experimentation objectives.
- e. Copies of part three are being furnished to the addresses which are listed below. Others interested in obtaining a copy may do so by contacting the Commanding General, Headquarters, MASSTER.
 - (1) USA Combined Arms Combat Developments Activity.
 - (2) Defense Documentation Center.
 - (3) HQ, MASSTER.
 - (a) DCofS, Operations and Plans, Quality Control and Analysis Division.
 - (b) DCofS, Personnel and Administration, MASSTER Technical Information Center.
 - (c) Science Advisor.
 - (d) USATRADOC Liaison Officer.
 - (e) Commander, AMC Field Support Activity.

LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

AC - analysis console
ACE - airspace control element
ADP - automatic data processing
ASCII - American Standard Code for Information Interchange
BICC - battlefield information coordination center
CONOPS - continuity of operations
CPX - command post exercise
CRT - cathrode-ray tube
DA - Department of the Army
DEVTOS - developmental tactical operations system
DTOC - division tactical operations center
EEA - essential elements of analysis
FSCC - fire support coordination center
FSE - fire support element
GDD - group display device
IBCS - integrated battlefield control systems
MB - map backgrounds
MIOD - message input-output device
MN - materiel need
PADC - placement accuracy and display completeness
RAM - reliability, availability, and maintainability
SSE/EWE - signal intelligence support element/electronic warfare element
TACP - tactical air control party
TEU - timeliness and ease of use
TOC - tactical operations center
TOS - tactical operations system
USACDC - United States Army Combat Developments Command
USAMC-ECOM - United States Army Materiel Command - Electronics Command
UTM - Universal Transverse Mercator
VDD - viewability of displayed data